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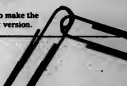
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USERS & UNIX

Unix is terse and jargony, a hacker's delight. It is not really a user's operating system.

By Robert Byers

Unix could well be called the Once and Future Operating System. Widely used since the mid-1970s, it seems destined to become the operating system standard for upscale micros as well as many larger computers.

Developed at AT&T's Bell Laboratories in 1969, Unix was a multiuser, multitasking, interactive system at a time when many computers were still batch processors fed by punched cards. Unix very rapidly became a darling of the computer science community, and by 1974, there were more than 600

Unix installations in place.

Although the number of Unix users continued to grow slowly but steadily, it appeared for a time to be just one more system whose time had passed. Many data processing managers were not convinced that AT&T was serious about supporting its operating system.

With the microcomputer explosion of the early '80s came a handful of supermicros based, for the most part, on the Motorola, Inc. 68000. One attraction of the supermicros was that they had the CPU power to be multiuser, multitasking and interactive. In fact, if they didn't, there wasn't much of a market for them. The supermicros needed an operating system as well as application software to become commercially viable.

Most hardware manufacturers cannot afford to develop and maintain their own software. So it seemed only natural they would turn to Unix. It was there. It worked. And there was a library of readily available software. Then, in the spring of this year, AT&T announced its own line of Unix-based

supermicros, the 3B series. This commitment is sufficient to ensure Unix will become the operating system standard for the supermicros.

As an operating system, Unix controls the operation of the hardware. It is responsible for managing the computer's resources, memory, CPU and disk storage as well as the interface to external devices such as terminals and printers. When more than one user is on the system, it allocates resources to users and arbitrates conflicts. It keeps track of what is stored on the disks and where disk files are located. It provides the interface between application programs and the hardware.

Unix requires a relatively large system by microcomputer standards. About the minimum usable configuration would be the IBM Personal Computer XT. Unix itself needs about 1.5M bytes of disk space. This space takes care of the core operating system (called the kernel), together with associated utility programs.

A good part of the value of Unix lies in these utility programs. They give the application programmer a



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"YOU WANT UNIX? WE'VE GOT UNIX!"

By Glenn Rifkin

At least 85 vendors have introduced some version of Unix on their systems. Counting micros, minicomputers and mainframes, there are more than 250,000 Unix-based systems in place. More than 160 application software packages are available for the various Unix versions with more being announced weekly it seems.

It is perplexing to both developers and industry observers that Unix — or any operating system, for that matter — is attracting so much attention in the end-user market of today. Bill Joy, developer of the Berkeley 4.2 version of Unix, has said, "Operating systems are like underwear. No one really wants to look at them."

In Unix's case, however, everyone is looking. And the major vendors are acting, conceding that Unix-based machines are required in their product lines. The question is not so much when Unix will become king, but how much of the kingdom it will claim.

The following sample shows how some major vendors are integrating Unix into their product lines.

AT&T

The recently unshackled telephone company is pushing its operating system as not only the foundation for its own product line but also the standard for the industry. Prior to divestiture, AT&T did little to promote Unix except to give it for a nominal fee (\$200) to universities. Unix was usually the first operating system young computer whizzes touched, and today there are thousands of C-level programmers who would rather turn in their keyboard than give up their Unix.

According to Stuart Mencher, director of data systems marketing for AT&T Information Systems, the company thinks Unix is simply the best operating system available and now AT&T is positioning itself to make it a de facto standard. Toward that end, the company introduced Unix System V Release 2, the latest upgraded version, and is licensing it throughout the industry.

AT&T also has signed cooperative agreements with such firms as Microsoft Corp., Ashton-Tate, Inc. and Digital Research, Inc. (for more microcomputer application software offerings) and Motorola, Inc. (for

the portability of Unix to 68000-based microcomputer systems). System V is also the basic operating system for AT&T's 3B line of computers, introduced earlier this year.

"We are positioned to be a leader in this market, and as the inventor of the product, we have to be the best," Mencher said. "That's a double-edged sword, because there are a lot of others out there competing with us."

Ironically, AT&T introduced its personal computer offering, the 6300, as a system based on Microsoft Corp.'s MS-DOS. Unix was conspicuous by its absence. Speculation was that AT&T showed market savvy by not bucking the IBM Personal Computer domination. Mencher admitted that AT&T is looking at the possibility of running Unix on its personal computer (or perhaps on an enhanced workstation expected this fall). And in fact, with the PC Interface, the 6300 can access the power of Unix by linking the MS-DOS operating system in the personal computer to the 3B2 desktop supermicro.

AT&T has introduced a vendor involvement program encouraging

software developers with Unix programs to contact the company. "If we are interested, we will fully support the product," Mencher said. "If not, we will still list it in a directory of Unix software that we publish. We've already had more than 800 inquiries."

AT&T will also be introducing Unix on a Westinghouse Electric Corp. 32000 chip, which will offer better price/performance, according to Mencher. "The WE32000 will set us apart," he said.

IBM
IBM put its imprimatur on Unix when it announced its Unix-based Personal Computer Interactive Executive (PC/IX) operating system in January. Developed for IBM by International Systems Corp. of Santa Monica, Calif., PC/IX is based on Unix System III.

On smaller systems, CP/M and MS-DOS were adequate. But when the need for multiuser, multitasking power became necessary, it was easier to adapt Unix than to stretch CP/M.

PC/IX, designed for the Personal Computer and Personal Computer XT, contains all of Unix's standard features along with a full screen editor that reportedly makes it easier for single users to use and maintain.

PC/IX can reside with other operating systems on a fixed disk so that more than one system is available to

the user. The product is reportedly able to provide programs for file transfer to and from IBM's PC-DOS operating system.

Relatively unknown is the fact that PC/IX is not IBM's first foray into the Unix world. IBM Instruments developed a version of Xenix (Microsoft's Unix look-alike) two years ago

for the IBM 9000 processor; and another version of Unix for the Series/mini computer was made available only to a limited IBM customer set.

IBM has also announced a limited offering of Unix for its VM environment—specifically on the 4300 series supermainframe—which is available to customers with "special requirements."

It is the same version of Unix as on the Personal Computer, expanded to fit the VM environment.

In August, IBM announced its Personal Computer AT, an Intel Corp. 80286-based high-end multitasking personal computer. At the same time, the company announced IBM PC-Xenix to run on the new machine. PC-Xenix reportedly allows two additional terminals to share the AT's processing power in either a multi- or single-user environment.

Though the company wouldn't speculate on the future availability of Unix for IBM's entire product line, Pat Kearney, director of programming for IBM's Information Programming Services group, acknowledged that Unix has become a requirement in today's market and the company is developing other Unix products.

"We are actively supporting Unix," Kearney stated. "Our customers are asking for it, and we see it as a significant business opportunity."

Kearney pointed out that IBM's version of Unix is "very much a real implementation of Unix, very pure and close to the standard Bell Unix." Bob Blake, manager of product development for PC/IX, added that though Unix can be "terse and unfriendly," IBM has gone a long way to make it clean and crisp. "Someone without Unix experience may find it hard to use," Blake admitted.

Thus far in beta test sites, efforts to port applications over to PC/IX have worked relatively well, according to Kearney. IBM has also brought out a Fortran 77 compiler and offers other applications such as Interactive's Inmail, Innet and PChart (a file transfer program).

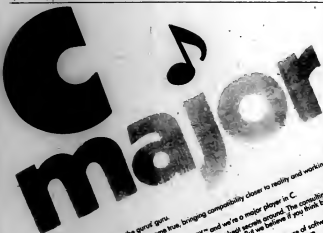
In fact, said Kearney, IBM worked closely with AT&T on the PC/IX development. Far from locking horns on AT&T's home turf, the two enjoyed a "very cordial and productive" relationship.

Analysts tend to agree that with IBM and AT&T behind it, Unix can't fail. Both Kearney and Blake are wary of placing standard status on Unix just yet, however. "I don't think the perfect operating system has been written yet," Blake said. "Unix has some unique strengths, especially in that it has been ported across a broad range of processors. But there are still a lot of requirements that the marketplace will address."

DIGITAL EQUIPMENT CORP.

Considering that Unix was created in the 1960s on DEC's PDP-7 mini-computer, the Maynard, Mass.-based computer giant decided it was high time that it treat the Unix market seriously. DEC entered the fray last year with its VTM-11 Unix operating system for the PDP-11. VTM-11 was based on Version 7, with enhancements for application development and porting.

Earlier this year, DEC renamed VTM-11 as Ultrix-11 and introduced Ultrix-32 for its VAX line of superminis. Ultrix-32 is based on the Berkeley 4.2 version of Unix, and on Sept. 11 the company announced a subset available for the recently



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introduced Microvax. In June, DEC introduced Pro/Venix, a Version 7 Unix developed by Venturcom, Inc., for the DEC Professional 360 microcomputer. Pro/Venix product for the DEC Rainbow personal computer is currently in the works, according to Bernie Toth, DEC's marketing manager for Unix.

Toth pointed out that Venix and Ultrix-11 are very similar in that they were both derived from Version 7. He also noted that applications running on Ultrix-32 can be ported to VMS, DEC's proprietary operating system for the VAX.

DEC has also introduced VNX, a program for product development which integrates Unix into the VMS environment for software development work. In that vein, the company developed the VAX-11 C programming language to generate optimized, sharable, position-independent code in the VAX/VMS environment.

DEC's interest in Unix has been growing over the past six years since the company started to track the operating system's progress, Toth explained. Since AT&T is DEC's largest customer, it was important to monitor the company's direction. DEC decided more than a year ago to support Unix on the open market.

"It was not a defensive move," Toth said. "Our customers actually demanded Unix. But that wasn't clear until just recently. In 1982, there were only 25,000 Unix installations. By 1983, that had grown to 100,000. That represented a significant market force."

Toth believes that it was the advent of the supermicro that was the boon to Unix. On smaller systems, CP/M and MS-DOS were adequate, but when the need for multitasking power became necessary, it was easier to adapt Unix than to stretch CP/M.

DEC chose to employ Version 7 (with Berkeley enhancements) rather than follow AT&T's System V because AT&T, according to Toth, is more interested in the office automation market — to which System V is more suited — while DEC has no plans for Unix there. Toth pointed out that DEC is quite satisfied with its All-in-One system for office automation and sees Unix as appropriate for its scientific and engineering customers.

The major focus now for DEC is getting third-party developers to produce application software for Unix. "It's a new phenomenon," Toth said. "Customers are asking for an operating system; they're asking for Unix."

WANG LABORATORIES
Wang is not particularly interested in seeing Unix become an industry standard.

On the other hand, the company felt it could no longer ignore the operating system altogether.

In March, Wang started shipping UVS, an operating system environment that integrates Unix System V software with the Wang VS operating system. This attempt to give customers "the best of both worlds" at the very least puts Wang in the Unix market, although it is not a ringing endorsement.

Aaron Zornes, Wang's

manager of product marketing for software, said that the company wanted to offer the strong programming capabilities of Unix to its customers. For virtually all other applications involving screen and data management, Wang believes its VS operating system is superior.

Nonetheless, Zornes insisted that Wang's entry into the Unix market was not a defensive one. "Unix is a commodity," he explained. "We do a lot of business with the fed-

eral government and with the Bell operating companies. Both of those areas have large investments in Unix. We wanted to open our machines to run any software our customers need without forcing them to buy another piece of hardware."

Though Unix is not currently available on other Wang product lines, UVS represents a strong commitment on Wang's part, Zornes said, since the VS system is the company's premier product.

With UVS, users can reportedly access both native VS and Unix facilities from the same workstation and change from one environment to the other with a single command. Wang is expected to announce a multitasker, multitasking personal computer running System V Unix within the next few weeks.

UVS also includes a Unix-to-Unix file transfer program, C, Fortran 77 and Rat-for compilers, Programmer's

MARKET

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With a number of products designed to be developed and sold the most marketable software for micro and

HP plans to announce in October or November a personal computer running only Unix.

Workbench, a software and management facility, as well as the troff/nroff utilities for text and document editing, formatting and typesetting. Though Wang added sev-

eral layers of menus where appropriate, UVS retains the basic shell of System V. According to Zornes, many vendors opted for System III or Version 7 simply because

they had products out before AT&T announced support for System V.

Wang's development work began later, and it seemed to make sense to follow AT&T's lead.

Wang's target market within the government and Bell operating companies are those "who require the ability to port Unix applications and are striving for the compatibility Unix is attempting to offer," Zornes said.

Despite Wang's Unix of-

fering, it is clear the company is less than thrilled with the commodity operating systems such as MS-DOS, CP/M or Unix.

In fact, Wang presses the point that perhaps the best thing about its Unix offering is that it allows access to Wang's own word processing, relational data bases, electronic mail and other Wang programs.

"If it's widely available, why not accommodate our customer base?" Zornes

asked. "We're not endorsing Unix as a standard, we're just making our machines more versatile."

HEWLETT-PACKARD CO.

HP has defined the computation needs of companies as falling into four distinct categories: commercial data processing, office automation, manufacturing and engineering and product development. According to Doug Hartman, HP's product manager for Unix-based systems, the company plans to make Unix available in all these areas.

HP customers, however, should not hold their breath waiting. The development of Unix across HP's product line will take place over "the next few years." Currently, HP offers HP-UX, its version of Unix, only on its HP 9000 superminis and superminis, which are aimed at the engineering and computer-aided design market. HP-UX on the 9000 was announced in November 1982 and is based on Unix System III. Hartman said that HP will be offering System V compatibility on the 9000 in early 1985.

In the commercial business and office automation markets, HP is investigating other Unix activity, but no products are ready for announcement yet. "Unix is a long way from being a good manufacturing tool, and there is a real question whether the QA market wants it at all," said Hartman. Nonetheless, HP, like other vendors, sees Unix as a potential business opportunity and will use it "to help implement our overall HP strategy."

Hartman indicated that HP plans to announce in October or November a personal computer running only Unix. The product, said to be in the \$4,000 price range, will be transportable and will incorporate new display technology. According to Hartman, it will be more powerful than Apple Computer, Inc.'s Lisa but cost less.

"There's a big segment of our audience that needs multitasking instrumentation control," Hartman explained. "This machine will run Unix for less money than anything on the market."

HP is also planning to bring out Unix on either its HP 3000 minicomputer or offer a new machine with a Unix option.

PRIME COMPUTER, INC.
Prime has not officially entered the Unix marketplace, but it will likely announce its Unix offering before year's end. The company, which has been playing catch-up in many of its markets recently, was caught somewhat behind in the Unix game. But Joanne Wombold, systems marketing manager for Unix and user interfaces, doesn't

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believe it is too late.

"Unix has generally been available on small systems. Its effect on systems over \$100,000 is still unknown," Womboldt said. "We think our timing will be right within months."

Prime has been working since June 1983 on a Unix offering in conjunction with Human Computing Resources of Toronto, a Unix systems house. When it is finally announced, Prime's offering will be available across its 50 series of minicomputers — from the 2250 through the 9950. Like Wang's UVS, it will be totally integrated with Prime's proprietary operating system, Primos.

"We will offer Unix as a complement to Primos," Womboldt explained. "Users will get both on the same system and can use both simultaneously. A Unix user can exist on

the system without any prior knowledge of Primos."

Prime is employing AT&T's System V version of Unix, betting that AT&T's commitment to the product will lead to industry standard status.

"We're trying to give our customers straight System V for standardization and portability," Womboldt stated. "The added benefit is the value of Primos."

The low-level portions of the Unix shell will be mostly provided by Primos, Womboldt explained, and the product will incorporate both the Bourne shell from AT&T and the Berkeley C shell. Prime's implementation reportedly will offer more than 160 utilities, and its modular structure will afford access to all of Prime's languages. In addition, there will be standard Fortran 77, Cobol-74 and Pascal compilers and the troff-

noff text editing and manipulation commands.

What Prime brings to this Unix implementation, Womboldt added, are its strength in virtual memory, its distributed file system, improved security, source-level debuggers and the opportunity to interface across Prime product lines with such offerings as the Medusa computer-aided design and manufacturing unit.

Like other major vendors, Prime was not quick to jump on the Unix bandwagon. Womboldt explained that Prime felt its own program development environment was good enough and "there was no need to migrate to Unix." As Unix gained in popularity, however, Prime's customer base started to demand it. "It's becoming a requirement," Womboldt said.

NCR CORP.

NCR brought out its Unix with the Tower line of minisuperminis in the first quarter of 1983.

"The trends in working with large accounts indicated a growing concern with industry standards, compatibility across the market," said Gary Horning, program manager in product marketing for the U.S. Data Products Group. NCR saw a need to respond to the excitement Unix was generating and wanted to work on its potential in the business sector to make it useful throughout large corporations, not just in development.

"Unix had always been a powerful software development product, but if you set down a programmer or clerk/typist or secretary, they would tear their hair out in a matter of minutes," Horning said. As a solution, NCR developed five user access levels, or shells: application and user, procedure analyst, system administrator, application developer and system support analyst. They are intended to satisfy everyone from analysts to managers and secretaries. "The idea is to take advantage of the expertise of each level of user," Horning said.

Tower Unix also offers power failure recovery capability.

Early versions of Tower Unix were based on Version 7 and System III, and Berkeley features have been added. System V enhancements will be out soon, according to Horning.

HARRIS CORP.

Harris intends to offer Unix for all of its superminicomputer systems beginning next year. Core capability will be available in the first quarter, with more features coming through the year. By the end of 1985, users will have a full-blown Unix environment, according to Rick Maule, director of marketing.

A significant portion of the market is looking at Unix as a de facto standard, Maule said. "Many users are trying to standardize on Unix to protect themselves. It has become a requirement for them in planning."

Harris' goal was to develop its Unix version to achieve complete compatibility with its native operating system, VOS. The company took advantage of the fact that VOS was heavily influenced by Unix early on.

"We have a series of major customers who want to have Unix compatibility, to be able to take an application from one system to another and have it behave identically," Maule said.

Harris claims it will be able to do just that. With its implementation, "it's not a do-or-die situation picking which operating system you want to work with," he said. Users will be able to switch between the two without logging off.

When the VOS/Unix environment (VUE) is complete, Harris users essentially will be working with Unix System V, with some Berkeley version extensions.

Maule observed that Unix is an even bigger issue for the company's prospective customers than for current ones. "It's every other there's at least one Unix buff. Management wants to provide them with the appropriate tools," he said.

Glen Riffin is senior writer for Computerworld Office Automation magazine. He also has written for The New York Times, the Los Angeles Times and Sports Illustrated.

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SOFTWARE FOR ALL SEASONS

This sampling of Unix-related software is meant to reflect the wide range of products coming to market as the operating system gains commercial importance. We do not imply that these products are superior to any others. All descriptions here are based on vendor-supplied information.

Applix, Inc. Southboro, Mass.

Alta, an office software system running on Unix, is targeted for resale by large OEMs in the computer and telecommunications industry. Alta offers "active integration" to combine different types of information (text, drawings, spreadsheets and so on) into a single document.

The Intelligent Document Composer reportedly provides continuous intelligent formatting assistance during text creation and editing, freeing the user to focus on editorial content rather than form. The Universal Graphics Editing combines freestyle drawing capability with ability to draw standard business charts automatically.

Onyx Systems, Inc. San Jose, Calif.

The Onyx Office software claims to be the first integrated package for Unix-based, 16-bit microcomputers. Onyx Office combines the capabilities of word processing, electronic spreadsheet and a data base manager with a user-friendly menu shell. Options include a development system and electronic mail package.

With this product, files and data reportedly can be transferred or moved between applications. For instance, information from the word processing application and the electronic spreadsheet can be combined or transferred to the data base.

In June, Onyx introduced two multiuser micros — the floor standing C5012V and the desktop C5012D. Onyx was the first microcomputer manufacturer to offer Unix commercially on a 16-bit micro.

Pathway Design, Inc. Wellesley, Mass.

Pathway signed two contracts this summer to provide Unipath, a micro-mainframe product operating under the Unix-compatible operating system called Unice (from Charles River Data Systems, Inc.). Unipath reportedly will enable simultaneous micro-mainframe communications for up to 32 devices in Systems Network Architecture/Synchronous Data Link Control and Binary Synchronous Communications networking environments. Unipath is resident on the hard disk of a 32-bit supermicrocomputer system. Pathway's

Unipath will be distributed with Charles River Data's Universe 66 supermicro and with Visual Technology's supermicro System 2000.

Visual Intelligence Corp. Amherst, Mass.

Dataviews is an interactive graphics software system that can display dynamic data in real time in engineering, scientific and business applications. The program runs on Unix and Unix look-alikes on computers ranging from 16- and 32-bit micros and supermicros through superminis.

Dataviews takes data such as temperature and pressure in a boiler room or current commodities prices and displays it in various formats. The user views up-to-the-second changes through multiple viewports on the screen.

Signa Design, Inc. Englewood, Colo.

In July, this manufacturer of computer-aided design systems upgraded Berkeley 4.2 Unix software and the Motorola, Inc. 68010 microprocessor, increasing the speed and power of the Signa III. This system is a stand-alone 32-bit workstation capable of local-area networking and distributed processing. Users typically include architects, engineers and contractors producing design drawings and construction documents. A 68010 microprocessor and color monitor are included in each workstation.

Visual Engineering San Jose, Calif.

The National Computer Graphics Association's May conference was the forum for announcing business and engineering graphics packages based on the industry standard Graphical Kernel System. All Visual Engineering products were written specifically for the Unix environment in the C language.

Visual-GKS and Visual-C-Chart offer systems and applications programmers graphics functions that simplify writing programs incorporating graphics. Visual-Pro-Chart enables business end users to produce easy business presentation graphics.

Legical Software, Inc. Cambridge, Mass.

Softshell, a full-screen interface, is said to offer users direct access to even the most complex programs and packages on the market. The attempt here is to simplify use of the hierarchical file and command structure while keeping the power of the piped and I/O redirection capabilities. The screen is divided into the window at the top and the scroll at the bottom. The window size varies according to the space needed by the command. Users can take advantage of the full-screen menu mode, which categorizes Unix commands by function with brief descriptions, or enter commands directly in scroll mode.

Dataviews displays three-dimensional vector fields in a study of effects of airflow on nearby vehicles and noise cones.

Relational Database Systems, Inc. Palo Alto, Calif.

Two separate data base management systems have been developed to run on 16-bit Unix and Unix-compatible machines. File-it address the business professional or casual user with an emphasis on user friendliness. The more sophisticated Informix is geared to the computer expert.

Accore Technology, Inc. North Natick, Mass.

Seal Equipment Corp.'s Classified Software Program accepted in July Accore Technology's spreadsheet modeling program, Supercomp-Twenty. Companies now running the program on their Unix machines include Alcos Computer Systems, Inc., Fortune Systems Corp., Perkins-Elmer Corp., Plexus Computer, Inc. and Onyx Systems. Supercomp-Twenty allows users to share work, access corporate data bases and transport complete models on machines from micros to mainframes.

Interleaf, Inc. Cambridge, Mass.

The OPS-3000 extends word processing to include start-to-finish production of documents containing multiple type faces and business graphics. This model includes a 32-bit workstation, graphics controller, laser printer and proprietary software.

Lantech Systems, Inc. Dallas, Texas

Hundreds of IBM Personal Computer applications written in Basic can be compiled to run under a Unix-compatible operating system called Unetix. That ability is the result of an agreement between Applied Technology Ventures, Inc. and Lantech, which will distribute the ATV/Basic compiler as an option with Unetix. Unetix is a "from scratch" multitasking operating system that is compatible with Unix software and was designed for networking of micros.

Emerald City, Inc.

Reveron, Canada
Emerald One combines six office tools into an integrated package — communications, information handling, decision support, document preparation and presentation, time management and system administration. Emerald One runs on any hardware that supports the Unix operating system — Version 7, System III and System V. Scheduled shipment date is this month.

Unetix features a multitasking architecture.

YES, IT RUNS ON MAINFRAMES

By Donald O'Shea



The demand is there, right now, for another surge in Unix performance.

Laboratories and numerous other technical computer centers grew, the amount of data fed to these programs grew also, the simulation models became more complex

and the demand for a more powerful Unix engine increased. The supermini was the answer to this call — in particular, the VAX-11/780 from DEC. There are proba-

bly 2,000 VAX-11/780s running Unix today, and the number is growing rapidly.

The individual applications are still multiplying in size and complexity. The circuit simulator written in 1977 to run under Unix on the PDP-11 has been extended again and again. The circuit, which may have started in life as a printed circuit board with a fistful of discrete components, is now a single, very large-scale integration (VLSI) chip with

thousands of integrated components. The simulator can no longer run on a PDP-11 — it would take 40 to 50 hours to execute. Even on a VAX-11/780, it takes 14 or 15 hours.

To make a change to the circuit is a fairly big undertaking. The simulator data may have to be altered several times in order to ensure the correct functioning of the design change. Each iteration may take an overnight computer run. (Back to the days

of batch processing!) So a simple change to fix an engineering snag on a product will take a week or two to check out on the simulator.

Performance demand

The demand is there, right now, for another surge in Unix performance. DEC has produced the VAX-11/785, which will help out to a small extent, as will the 9000 series from Gould, Inc. To solve the problem of the circuit simulator, however, performance must be increased by a factor of 20 to 40 times that of a VAX-11/780.

The only way this kind of power can be provided in an economical way is to make the operating system available on the largest main-frame computers. Amdahl Corp. has marketed Unix-based subsystems under VM/370 since 1981. The company has now implemented Unix as a native operating system for the 580 series processors, and UTS, as it is called, is currently running at several customer sites as part of an early installation program. On a Model 5860, a Unix application runs 20 times faster than it does on a VAX-11/780.

Development is currently under way to run UTS on a Model 5870, a dual-processor machine that operates at 22 million instructions per second. Typically, dual processors perform at about 1.6 times the power of the corresponding uniprocessor. So the requirement for a Unix processor 30 to 40 times the power of a VAX-11/780 can be met in the short term.

Unix communications

Among the technical problems Amdahl has had to face in moving Unix to IBM 570 architecture machines, none has been more important than providing satisfactory support for full-duplex Ascl terminals. Few self-respecting Unix programmers like the IBM 3270-style block mode, half-duplex terminals which dominate the main-frame world.

With a 3270-type terminal, when the user depresses a key, the appropriate character is displayed on the screen. Unless one of a number of (manufacturer-defined) special keys has been hit, the keystroke is accumulated in a buffer. When one of the special keys is hit, for example, "enter," the contents of the buffer are sent to the applications program.

With a full-duplex terminal, each keystroke is transmitted to the application program as it is entered. The application can determine which action to take. Normally, the appropriate character is transmitted back to the screen on the terminal. But that need not be the case. The application may dynamically give special significance to any key. For

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AMERICAN INFORMATION SYSTEMS

instance, when an "A" is keyed, the application could display a "1"; or when an "m" is typed, the screen might be cleared. This real-time relationship between the keyboard, application and screen provides the power of text editors such as "vi", beloved of the Unix community.

Amdahl built full-duplex Ascl terminal support into UTS. Consequently, application programs such as vi and "emacs," another full-screen Ascl editor, run on the mainframe Unix without modification. The full-duplex Ascl support also allows us to provide "ucsp," a very common Unix-to-Unix communications protocol.

In UTS, Unix has been extended to include functions to allow its use in a large data center. "Extended," incidentally, is the important word. What we have done is to port Unix System V Release 2 to the 370 architecture and then add extensions. The portability of applications that an AT&T-defined standard Unix will allow is very important to the pro-

The VM-based Unix recently made available by IBM certainly does not lead one to believe that the corporation is vigorously pushing Unix.

ported from one vendor's hardware to another, is not a means toward account control.

The VM-based Unix recently made available by IBM certainly does not lead one to believe that the corporation is vigorously pushing Unix. More likely, we are watching a replay of the APL story, in which a small number of enthusiasts within IBM tried, for many years, to gain corporate en-

dorsement for their product. APL did make it out the door, but only just!

VM/IX is not a generally available product; it is a Program Request for Price Quotation that will be sold only to customers with special qualifications. Furthermore, it is not based upon Unix System V, but upon the older Unix System III. And it cannot run on the largest IBM machines.

VM/CMS will be IBM's vehicle for

competing with Unix. There are, however, some reasons why Unix will win this battle.

Universities have in large part been reluctant to use VM for undergraduate computing, so graduates do not go into industry with a knowledge of how to program on it. VM has not been widely accepted on campus because of its complexity. It lacks Unix features such as pipes that allow one to create very powerful programs from simple building blocks; the absence of compiler tools such as "yacc" and "lex" makes language development difficult.

VM is also expensive on a per-user basis. Disk resources, memory and CPU requirements, as well as system programming time, all increase as packages are placed on VM to make it more productive and user friendly. In addition, large 3270 networks are

VM/CMS will be IBM's vehicle for competing with Unix.

cessing industry. We enthusiastically support this standardization drive.

The extensions we have made are varied. Memory management obviously required paging. System support for everything from 3270s to solid-state drums has been added. The 3270 support includes an exceptionally good full-screen editor.

Tape library management and printer spooling are other areas of vital importance in a large data center, while they matter little in a small engineering laboratory where a VAX or TDP machine may have one tape drive and a single printer. We have enhanced these areas as well.

Communications with other mainframes running MVS or VM are important when Unix is placed in the DP shop. Using channel-to-channel adapters or high-speed communications lines, jobs can be submitted from UTS to MVS or VM, and the results can be sent back to UTS.

Many of the Unix commentators like to express the opinion that IBM will determine what is going to happen to Unix. This is not a foregone conclusion.

IBM's interests are best served by promoting its proprietary operating systems, such as VM/CMS, rather than embracing another vendor's software. Promoting a system like Unix, whose strength lies in the ease with which application programs can

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There has been a quiet revolt over the past 10 years. Programmers want user friendliness, too, and they measure it by the speed with which a system can show them the results of their work.

uncommon in university computer labs, providing yet another barrier to VM implementation. The administrative data center, which may have these facilities, is traditionally managed quite apart from the academic machines. And while the large computer center in the university typically runs the payroll, student accounting, class scheduling and so on, it does not generally provide a time-sharing service for the campus. As a result, micros, minis and superminis prevail.

VM/CMS is not going to disappear overnight. Many of its features may be offered under MVS in the future. We do believe, however, that it

never has answered the needs of a large portion of the data processing community who use it. These people use it because there has been no serious alternative. But there is one now — Unix.

With more than 15 years of development behind it, plus the efforts of some of the brightest people in the computing business, Unix has come of age. The Unix system has grown to meet the needs of its users — computer scientists, engineers and especially programmers.

What are the reasons for the groundswell demand for large systems Unix?

1. The number of Unix users graduating from universi-

ties throughout the world over the past several years generated a large and growing pool of C programming talent.

2. The growth of Unix as a base for developing software in the defense and communications industries virtually mandated delivery systems commensurate with the size of these applications.

3. The portability of applications, which follows from implementation of Unix on everything from a personal computer to a 5870, makes it easy for cottage developers to write code that can later handle massive amounts of data when run on a mainframe.

4. User friendliness is a concept we normally apply to applications systems used by the non-IT professional — the airline reservations agent, the bank teller, the insurance agent. Computer professionals are supposed to fend for themselves. Their ability to wrestle with complexity is taken for granted. There has been a quiet revolt over the past 10 years, however. Programmers want user friendliness, too, and they measure it by the speed with which a system can show them the results of

their work.

There are three components required in any system that is intended to respond to this revolution.

A high-level language is required, but not so "high level" that the programmer is unable to manipulate the hardware with which he is working. The C language, an integral part of Unix, answers this need. It is more powerful than assembler yet able to manipulate varied hardware devices easily.

Once the right high-level language is available, it must be possible to use it easily. That is to say, it should not be necessary to know a great deal about the system before you can compile your first program.

The final desired component in such a system is the ability to manage source code easily in large development efforts. Unix subsystems,

such as Source Code Control System and the Documenter's Workbench, provide an integrated software engineering environment.

It has been a long time since a subject has caused as much controversy in the data processing world as Unix. This operating system is not, however, a fad. Portability, flexibility and a strong bias toward programmers will guarantee its future.

Now that a good implementation is available on 370-architecture systems, its future is unbounded.

Donald O'Shea is director of UTS Products at Amdek Corp. in Sunnyvale, Calif. He currently has business and development responsibility for Amdek's Unix-based products.

TYPOGRAPHY/GRAPHICS

The Job: We need a talented, creative person to be the architect of a powerful document production and graphic art systems, manning our software and hardware and limited only by your imagination. Existing hardware includes a color ink-jet printer, Duan Camera System, 300 dpi laser printer, a eight interactive color graphics systems connected to four Vix 780's running 4.2bsd.

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For more information contact:

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THE UNION OF C AND UNIX

By P.J. Plauger

The C language grew up with Unix.

When Dennis Ritchie decided to improve on the interpreted language B, a descendant of BCPL, he knew he wanted a compiled language for performance and a typed language for simple pointer arithmetic. And he knew he wanted to work under Unix because you could get more work done.

Thus was born the language of C in the early 1970s, at a time when Unix was ripe for recasting in a higher level language. And every time C failed to satisfy Ken Thompson's stringent expectations, Ritchie was there to tweak and trim his new invention to be a better sys-

tem implementation language. By the time a significant portion of Unix was rewritten in C, that first PDP-11 compiler was impressing a lot of dyed-in-the-wool assembler programmers (including this author).

The next thing you knew, people were talking about moving the Unix operating system to completely different computer architectures. What a challenge! The Interdata, Inc. 7/32, the Interdata 8/32 and the Digital Equipment Corp. VAX-11/780 were tackled almost in parallel and with remarkable success. Ritchie quickly heard about all the places where C got in the way and made the necessary changes.

C was not only powerful and efficient, it was also portable. And so, too, was Unix.

This is the C of Kernighan and Ritchie's best-selling book, *The C Programming Language*. This is the C that has been moved to many machines and to numerous Unix environments by users such as my own, Whittemuth, Inc.

This is also the C that paved the way for the widespread migration of Unix, because the vast majority of Unix code is written in portable C. Most of the rest is written in machine-dependent C for ease of maintenance. Only the irreducible minimum of any Unix implementation is written in assembler, ignoring a few

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heavily used functions that measurably affect overall performance.

The influence of C on Unix has not always been positive, however. As a language, C stands out as being particularly terse, almost parsimonious in expression. It also performs very few checks, so that innocent-looking expressions can have disastrous effects. Hence, a simple statement in C can possess stupefying power.

All of these statements

have been leveled as criticisms of Unix.

It's not that the file removal utility in Unix, for instance, has to be any more dangerous than the one under, say, IBM's PC-DOE. It's an easy matter to alter the source code of Unix "rm" to be just as picky as DOE "erase." But to the original author and all subsequent maintainers, deadly power is a thing to be prized, not kept in check.

And why is it called "rm"

instead of "remove" or "erase"? That C-style terseness again. It is the work of but a moment to rename the command or simply add a longer alias, but few Unix shops do so.

You don't have to be a C programmer to use Unix, but it sure helps to think like one.

Another pernicious influence of C on Unix was just alluded to in passing: It's terribly easy to modify the code. For ease of maintenance and

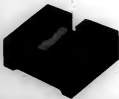
enhancement, this ability is a godsend. But in a world where literally scores of enterprises have a stake in enhancing Unix, such is a different direction. It's a standardization nightmare.

Look at all the versions of Unix currently available: Version 6, Version 7, Programmer's Workbench (PWB), 32V, System III and System V — all from AT&T alone! Then there are the re-packagings of Unix: Xenix, Venix, Tnix, Unixplus, to

name just a few. And then the rewrites: Idris, Unos, Coherent and so on. These flavors are remarkably alike, converting the diversity of sources, but they also differ in many surprising ways.

Few systems make it so easy to modify basic utilities or to rename them, or even to change the very language used to run commands. How does a software vendor hope to package an application if the options for the utilities needed to install it vary among customer systems?

The underlying reason for this unwarranted diversity is



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The Unix community is ghettoized by dialects.

the fact that so much basic code is written in C. First, the code itself is malleable; second, the love of malleability permeates everything else.

For years, industry observers have reported a lack of widespread packaged software for Unix. Always the stuff is just around the corner. Here is the reason why: The Unix community is so ghettoized by dialects that no one packaging has a potential marketplace of more than a few thousand systems.

Thus, a handful of C programmers can give you your own private Unix, but it will probably be too private.

If AT&T can get everyone to adopt standard packagings of System V, that situation may change. Or if IBM convinces the world that one of its (three) dialects of Unix is standard, that may change. Otherwise, the best hope is that the standards developed by /usr/group, the commercial Unix users' group, will be voluntarily adopted and prevail.

If all of this sounds bleak, it should also be viewed from another perspective. The criticism that C is a dangerous programming language assumes the existence of a safe one. And Unix has been criticized as not user-friendly, which implies that some system, somewhere, is user friendly.

If C is not safe, it is at least powerful; and if Unix is not friendly, it is at least cordial. No other language or operating system of comparable power does better.

P.J. Plauger is president of Whitesmiths, Ltd. in Concord, Mass., whose principal products include a broad line of C and Pascal compilers. Whitesmiths also sells the Idris operating system.



CAN THE HOLES BE PLUGGED?

T



(although in some Unix systems a user may be in several groups at once).

The file system contains data files, directories and devices (including a pseudo-file that permits access to kernel memory), which are arranged into a tree of arbitrary depth. The access control mechanism allows specification of access permissions to the owner of each file, a particular group and all other users. The access permissions are "read," "write" and "execute" for all data files and devices; "status," "search" and "modify" for directories.

The granularity of control that this mechanism provides is often insufficient in practice. For example, it is not possible to grant a maintenance group write permission to a directory, while granting a single other user group read access permission to the same directory. Access to any file requires search access to all superior directories (those between the file and the root node). This feature is a positive one in terms of security but has negative consequences because only one group may be associated with a directory.

It is not useful to have layered directories associated with different groups because these directories can not be traversed without "all" permission on all but the last directory. This makes it impossible to have layered access privileges; only vertical access distinctions are possible.

As a consequence of these weaknesses, many files and directories are configured to permit read access to most files by all users. In addition,

Current Unix security is weak, but the system's usefulness warrants the extensions necessary for sensitive commercial applications.

many users are given super-user privileges which permit them to bypass the protection of any file. These practices encourage browsing and permit disclosure of sensitive data.

These weaknesses may be overcome by the use of access control lists associated with each directory and file. The Multics operating system developed at MIT provides an excellent example of this mechanism. An access control list designates access permission by logical combinations of multiple users and groups. A reasonable, upward-compatible access control list mechanism could be incorporated into Unix.

In order to login to a Unix system, a user must present a valid user name and password. Passwords used for user authentication are encrypted, and the encrypted text is stored in a file accessible to all users. These public, encrypted passwords are subject to attacks by brute-force searches for strings that, when encrypted, match an encrypted password.

Even though this kind of attack cannot reasonably be used to explore all possible passwords, user selection of common words and names for

passwords makes the task tractable. The brute-force attack can be easily defeated by protecting the password file and by requiring users to select passwords that are not trivial.

Current formal (mathematical) software verification methods require that a system's security policy be implemented in a single body of code. Were Unix secure, the kernel would contain that body of code. Unfortunately, there are two mechanisms to bypass the kernel in its role as mediator of security policy: the privileged (super-user) process and direct access to kernel memory.

Early Unix design was constrained by the need to write a very small kernel. One technique used was to make the acquisition of system status information by user-level processes straightforward. Unix provides few status-gathering primitives, but instead, permits system status utilities to read kernel memory directly. Malicious users can use this capability to acquire passwords by reading kernel terminals I/O buffers. They can also determine the contents of files by reading selected kernel data buffers.

Another kernel reduction technique was to minimize the security mechanisms implemented in the kernel and permit processes running with the super-user privilege to be unconstrained by any Unix security mechanism. These processes can also execute privileged system calls. There is a large quantity of privileged user process code that may contain bugs or Trojan horses that could be discovered and exploited by knowledgeable users.

Given these weaknesses and the large number of specific flaws that have already been discovered, it is extremely hazardous to permit outside users (especially via dial-in) to have access to a Unix system.

Many of the weaknesses can be nullified by implementing restricted process environments. Access beyond a small portion of the file space enclosed by a restricted process environment would be prohibited, and no privileged processes could operate within it. Such a partitioning may be performed without modifying the Unix user interface and would make browsing outside of the partition impossible.

A secure system must have a distinct separation of roles among operators, site administrators and security administrators. A security administrator must be capable of setting a security policy that cannot be violated by a site administrator or operator. Unix has no distinct concept of operator, site administrator or security administrator. Operators are simply those users with membership in the group (or holders of the user ID) associated with system administration files. In practice, for an operator to be effective, he must possess the super-user password. This all-or-nothing approach, with its corresponding lack of accountability, makes a system operations staff especially capable of abuse.

An important feature of any system is that regular users should not be able to restrict other users from having access to system resources, including file space, CPU cycles and processes. On many Unix systems, a user may allocate all or only a slice on any file system to which he has access. This provision effectively prevents all other users from using that resource. Unix systems have only recently begun to provide mechanisms to limit resource allocation by users, and thus, to protect other users from the threat of denial of service.

Another security feature of importance is the ability to obtain and store an audit of significant system events. Unix, as implemented, cannot provide reliable auditing for two reasons. First, auditing requires a small set of points at which all system activities of interest can be captured. Unfortunately, Unix does not satisfy this requirement. Access may be made through a variety of untrackable mechanisms. Second, audit files on Unix are vulnerable to tampering. An effective audit trail must be kept and stored on a separate system (for example, a terminal access machine), which cannot be accessed by the Unix staff.

Military security requirements far exceed commercial requirements. These requirements specify that data be given a sensitivity label (for example, CONFIDENTIAL, SECRET, etc.) and, in essence, that users must have a clearance level at least as high as any data they attempt to read. A secure system must also guarantee that malicious users at different levels may not communicate. The use of covert channels, including the modulation of shared variables (for example, access control settings) and the modulation of shared resources (such as communications lines), must be controlled.

Bringing Unix into compliance with these requirements has proved extremely difficult. It requires the development of a formal security model, a design that can be formally verified to satisfy that model and an implementation that can comply with the design. This process means a complete reimplementing of Unix, with all of the associated risks, costs and stabilization effort. It has so far been very difficult to construct a kernel with an isolated security mechanism that also provides adequate performance.

In spite of the fact that current Unix security is weak, the usefulness of the system warrants the extensions required for use in sensitive commercial applications. The rapid rise of remote and distributed computing exposes systems to a very large number and variety of threats. Without security improvements, users will be restricted to small, non-distributed environments or those in which no sensitive data is present. A major implementation that satisfies military requirements, while difficult and costly, will allow significant new military and commercial applications for secure systems.

Glen Krouach manages the Unix and Environments Group at Gould Software Division in Urbana, IL.

Dave Healy is a senior member of the technical staff at the Gould Software Division with appointments in research and development groups.

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UNIX:
THE SEARCH FOR
A STANDARD

By Robert Marsh

One of the major controversies surrounding the growing popularity of Unix is the proliferation of different versions. How can Unix be a standard operating system when there is not even a single, standard version?

In June, a milestone in Unix standardization was reached with the adoption of the first vendor-independent standard for Unix-based and Unix-like operating systems. The new standard holds the promise of greatly increased compatibility among the various versions and should diminish, if not eliminate, the controversy over compatibility.

Work on the new standard began in the summer of 1981. An independent association of Unix users, /usr/group, established a working committee to define a vendor-independent standard. Representatives from major Unix-based hardware and software vendors were included on the standards committee to

ensure a range of views and interests would be represented. AT&T actively participated through representatives from Bell Laboratories, where Unix's development within AT&T continues today.

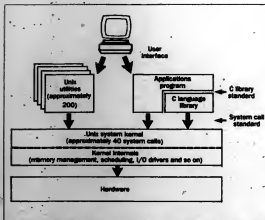
The need for a standard became more acute as Unix emerged as the operating system of choice for 16- and 32-bit supermicrocomputers. Digital Research, Inc.'s CP/M and Microsoft Corp.'s MS-DOS achieved standardization on 8-bit and 16-bit personal computers, respectively, through the efforts of their vendors, who rigidly controlled changes and enhancements to the software. In contrast, AT&T played the role of technology licensor rather than software supplier and introduced incompatibilities among its own versions of Unix. AT&T also plays the dual role of software supplier and hardware vendor in the Unix market.

A vendor-independent standard

thus becomes the only way to eliminate the inherent conflict of interest that lies behind any AT&T efforts to establish its particular Unix version as a standard.

The objective of the new standard is to establish an operating system specification that is vendor-independent yet functionally compatible with Unix. Operating systems that comply with the standard, whether derived from Unix or developed independently, offer a very high degree of applications portability.

This portability benefits every participant in the Unix marketplace. For hardware vendors, the standard is a fixed target for compatibility, eliminating the need to choose one version over another. For software developers, the standard is a framework for building portable applications packages. For end users, the standard encourages wide availability of off-the-shelf



Application portability is largely achieved by standardizing the Unix system calls and the C language libraries.

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A major contribution of the /usr/ group effort is agreement on a standard method for file locking.

Unix-based software that executes without change on hardware from various system manufacturers.

A primary problem in creating a standard is deciding exactly what to standardize. Unix is a large, complex operating system compared with the previous CP/M and MS-DOS standards.

A typical Unix implementation includes more than 200 commands and utilities and as much as 6M to 10M bytes of object code. However, the goal of application portability is largely achieved by standardizing two relatively small parts of the operating system, the Unix system calls and the C language libraries. The diagram shows how these two interfaces relate to the Unix system as a whole and to user application programs.

Two critical interfaces

The system calls are the fundamental interface between the application program and the kernel. The application programmer uses these calls to perform file and terminal input and output, to manage files and directories, to launch other programs and so on. The 39 system calls defined in the standard give Unix a very "clean" interface between the application program and the operating system. Popular MS-DOS applications (such as Lotus Development Corp.'s 1-2-3 and Micropro International Corp.'s Wordstar) often directly access internal operating system routines, creating a dependence on the internal structure of the operating system.

Unix applications interact with the kernel only through the system calls and are isolated from the internal structure. For example, different kernels may support virtual memory,

real memory or swapping schemes for memory management; yet still retain absolute compatibility with the system call standard.

This feature greatly increases the portability of Unix, since a hardware manufacturer is free to adapt the Unix internals to suit particular hardware.

The other Unix interface addressed in the new standard is the standard C language library. The library is a collection of utility routines frequently used by commercial application programmers. These routines include functions for mathematics, table sorting and searching, string manipulation, I/O formatting and encryption, among others. With these functions in the standard, application programmers are assured that programs that rely upon the library routines will execute properly under any operating system that conforms to the standard.

The standard does not include a definition of a Unix user interface, nor does it yet deal with utilities and commands. These interfaces vary much more widely among versions than the system calls and libraries and pose a more difficult standardization effort. More important, they tend to be application-dependent and are therefore poorer candidates for standardization.

An excellent example is the command interpreter, or shell. While the AT&T Bourne shell is the most widely used user interface today, software developers often favor the alternative C shell, developed at the University of California at Berkeley. In turnkey installations, the shell is often replaced altogether by an application-specific, menu-driven program. This flexibility and adaptability is one of Unix's great strengths, and efforts to standardize on a single command set or user interface that will suit all potential applications are probably aimed in the wrong direction.

Basis for standard

Although, the /usr/group standard is independent of any particular version or hardware implementation, its contents are based heavily on Unix System III from AT&T. Indeed, an operating system can be in full compliance with the standard and not contain a single line of "Unix" code from AT&T. Several such Unix look-alikes have already been developed.

The standard preserves the key characteristics that have made Unix popular, including:

- Multiprogramming: Multiple, concurrently executing processes are supported.
- Multitasking capability: Individual users of the system are uniquely identified and optionally organized into "user groups."
- Security: Access to files is controlled on the basis of the user/group organization.
- Hierarchical file system: A hierarchical directory structure is used to organize files.

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• **Pipes:** The famous Unix method for process-to-process communications is preserved.

The differences between the standard and the various Unix versions in popular use arise mostly from hardware dependencies or inconsistencies among the versions. System calls to facilitate user accounting, for example, are present in several of the popular versions (System III, System V, Berkeley) but are not included in the standard. Similarly, the details of terminal I/O control are left unspecified in the standard, although the system call to perform this function is included. Variations among the versions in the control of character echo, half- and full-duplex operation and similar low-level terminal functions made standardization at the detail level impossible.

A major contribution of the /usr/

group effort is agreement on a standard method for file locking. The standard specifies a system call for record-level locking of shared files to coordinate concurrent access by several users. While this feature is critically needed in commercial multiuser applications, it has not yet appeared in an official AT&T Unix version. Almost all commercial Unix system suppliers have added record locking to their implementations, however, and the standard gives this "standard Unix extension" more official status.

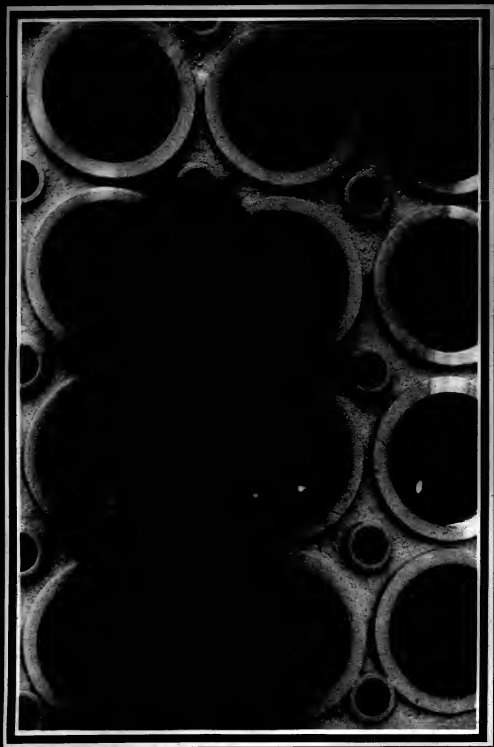
The standard is also highly compatible with Unix System V, which has been the focus of heavy advertising and promotional support with AT&T's entry into the computer business. The only major feature of System V not addressed in the standard is its shared memory and interproc-

ess communications facility. These capabilities, while important technical extensions to Unix, are new with System V. They have not yet found wide acceptance among Unix-based software developers but are probably excellent candidates for future addition to the standard.

Copies of the official /usr/group standard and information about membership in /usr/group can be obtained by writing to /usr/group, Suite 200, 4655 Old Ironsides Drive, Santa Clara, Calif. 95054.

Robert Marsh is chairman of the board, Pazzes Computers, Inc. in Santa Clara, Calif. He was one of the founders of /usr/group and its first president. He currently serves as a director.





YATES UNIX

The story of Unix is one of several software organizations working separately to take an operating system from its beginnings in a Bell Labs research environment to its present status as the premiere portable multiuser operating system. Although the resulting phenomenon is thought of as Unix, it goes by other names as well: 4.1 BSD, Xenix, Zeus, Regulus, Unos, PC IX, U1 trix and many more.

Since the initial release, universities have enhanced Unix. The most prominent example is the University of California at Berkeley. With research funding from the Defense Department's Advanced Research Projects Agency, Berkeley added virtual memory, the Lisp and Pascal programming languages, a data base management system and networking support to Unix. In addition, an enhanced user interface known as the "C shell" or "csh" made Unix more friendly to programmers, who could take advantage of the shell's features such as command history, which allows users to recreate their actions from any point.

As a result of Berkeley's enhancements, its versions of Unix (which go by a release number followed by "BSD" for Berkeley Software Distribution) became extremely popular in high-tech firms, especially defense shops. Since high-tech firms and universities made up the largest portion of Unix's early customer base, the BSD releases are still the most prevalent Unix versions on mini-computers, the machines typically used in such environments.

**Unix will be used
by the majority of
office workers and
small businesses
by 1989.**

At the same time, software houses were making commercial enhancements to bring Unix to the office. Microsoft Corp. is the most prominent, but Unisoft Systems Corp./S1 nplus is the most widely used, and Interactive Systems Corp. was the first to make available a commercial version of Unix. In addition, a number of companies are offering operating systems that look like Unix to the user but are not based on Bell Labs' source code.

Microsoft's Xenix is the best known derivative. The company included features to lessen the need for sophisticated system administrators, thus allowing Unix to be commercially acceptable for the microcomputers that were finding their way to the office. In addition, Xenix was ported to the most popular microprocessors, making a single version of Unix available across all of them. Finally, the inclusion of support made Xenix much more attractive to the nontechnical commercial world than Unix had been. With IBM's announcement of Xenix on the Personal Computer AT, its success as the micro Unix standard is assured.

Unisoft specializes in porting Unix to Motorola 68000-based microcomputers. IBM has been the most popular of Unix microcomputers, and it runs on more than half of all desktop machines.

Interactive Systems Corp., a software house to offer a complete port, enhanced Unix by adding office automation packages to its version of Unix, IS-Unix, which is available only for Digital Equipment Corp. minicomputers. Interactive Systems has recently been chosen as the supplier of Unix (known as PC IX) for the U.S. Personal Computer.

While Microsoft, Unisoft and Interactive Systems all started with source code supplied by Bell Labs, other firms took different routes to developing operating systems that looked like Unix. The best known are Whitesmiths, Ltd. (the developer of Idris), the Mark Williams Co. (Coherent) and Clear River Data Systems (Unos).

Because inexpensive Unix binary licenses were not available, companies like these decided to start from scratch in developing operating systems that appeared to be Unix but were not legally, thus avoiding the high price tag associated with a Unix source license.

Meanwhile, the developers at Berkeley and elsewhere were not sitting still. Berkeley's 4.1 BSD release was becoming a new standard in the high-tech community, and sales were picking up for Microsoft, Unisoft and other commercial vendors. Their enhancements ranged from making Unix run faster to adding application

software and support for real-time processing.

It is still not clear what the future will bring for companies developing their own Unix versions.

AT&T is expected to add slowly the enhancements that others have made, perhaps to pull Unix closer to 3B-specific hardware designs. Once a future incarnation of System V has enough enhancements to make it competitive in the office, there will be less room for Unix derivatives. AT&T has also been adding many of the Berkeley enhancements. With Berkeley in no position to support its own version of Unix, even die-hard BSD fans may slowly come over to System V and its descendants.

The other versions of Unix will be around, at least for a while, but it appears that their moment in the spotlight is coming to a close.

THE YEAR OF SOFTWARE

The lack of application software for Unix supermicros, critics say, is the deficiency that could doom Unix as a commercial operating system.

However, several forces will converge this year to eliminate this lack of application packages.

Today there are many custom applications for minicomputers running Unix. Perhaps more important, there are enough trained C programmers to provide the world with good application software. Missing from the equation has been a sufficiently large installed hardware base to make the writing and distribution of applica-

tions profitable.

Microsoft's Bill Gates explained: "When the Unix hardware installed base reaches 500,000 units, more software developers will deem Unix worth their application efforts." That milestone will be reached late next year.

C rewrites

In anticipation of more complex CPUs and operating systems for micro, many applications developers began rewriting their programs in C during the last two years. The portability of this language, which is emerging as the standard development language, ensures that these software companies will be ready for any operating system that might emerge as a standard — especially Unix, which is written in C.

Consequently, there are hundreds

of application programs, already written in C, which can be rushed into the Unix supermicro market as soon as the installed base expands to the point of making the effort profitable. That day is close, the catalyst being IBM's Personal Computer AT.

The AT runs MS-DOS and Xenix, Microsoft's implementation of Unix System III. Software developers interested in multitasking, multiuser applications functionality see Xenix on the AT as a potentially huge installed base. Many market opportunities have been created by the new AT's high random-access memory (RAM) limit (3M bytes), hard disk capacity (40M bytes) and more powerful 286 CPU. For the user to take advantage of these features more fully, Xenix must be used as the operating system.

AT&T has a vested interest in making it profitable for software developers to bring products to market. Recently, the AT&T Information Systems group set up several programs

AT&T has a vested interest in making it profitable for software developers to bring products to market.

to promote this process.

AT&T established the Independent Software Vendor (ISV), Vendor Involvement Program (VIP) and System V Library projects to accelerate the emergence of Unix System V as a standard. The strategy is to encourage independent software vendors to increase the quality and quantity of software on Unix-based computers. Software vendors in the programs receive a 25% discount on leasing a 386 computer. AT&T's distribution of the vendor's application (in the case of the System V Library program) and quality control consultation.

The ISV and VIP programs are similar, but controlled by different divisions at AT&T. The ISV program, developed at AT&T Technologies, is headed by John Evans, the software publishing manager. The emphasis here is to market products to value-added resellers. The ISV program concentrates on encouraging the production of horizontal applications, such as graphics packages and data base management systems (DBMS).

The VIP program, under the direction of AT&T Information Systems, is headed by Paul O'Brian. Since the information Systems division is geared toward end-user products, applications adopted are for vertical markets.

The Unix Systems V Library is a joint venture of Digital Research, Inc. and AT&T. The System V library publishes independently written application packages and offers them for sale on a wide variety of hardware.

These programs have been good for all software vendors, but they especially help vendors who have already established themselves in the Unix market. Invariably, these companies wrote an application package for the Unix minicomputer market,

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specifically for Digital Equipment Corp. hardware. As this market became saturated and as Unix moved down onto superminis, these vendors ported their products to smaller machines.

The most conspicuous success has been Relational Technology, Inc.'s Ingres DBMS package. Originally developed at Berkeley to run on the DEC VAX, Ingres can now be found on Unix hardware including popular models such as the Tandem Corp. Model 16, the Altos Computer Systems, Inc. 586 and the Zilog 8000. This summer, Relational Technology entered into a long-term development and marketing agreement with AT&T. Ingres was selected as the relational DBMS throughout AT&T's 3B product line, with Ingres/CS (Compact System) appearing on the 3B2.

Several other software packages have succeeded in the Unix market, including Multiplex (spreadsheet) from Microsoft; Informix (DBMS), Relational Database Systems; Horizon (word processing), Horizon Soft-

ware; Ultra Calc (spreadsheet), Olympus Software; Unify (DBMS), Unify Corp.; Q-1 (word processing), Quadratron Corp.; and MISII (accounting), Real-World Systems.

IBM GIVES ITS BLESSING

The sudden popularity of Unix is the result of several powerful forces affecting the industry:

- AT&T offering the 3B2, 3B6 and 3B20 products, a comprehensive line of computers running Unix as the primary operating system.
- AT&T's extensive print, conference and television ad campaign.
- IBM's announcement of PC/IX and the market's anticipation of further IBM/Unix announcements.

- Growing demands by corporate department managers for cross-vendor networks of personal computers,

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BSD 4.2
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FOS
Genix
HP-LUX
IS/1
Onix
OSL
Perpos
PC/IX
RTU
Sylb
System III
System V
System V.2
Trix
Unix
Uniplex +
Unisix
Unix
UNIX/VS
UTX
Venix
Version 6
Version 7
Xenix
Zeus

Company

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U.C. Berkeley
Aurigen Corp.
IBM
Bell
The Wollongong Group
Fortune Systems Corp.
National Semiconductor Corp.
Hewlett-Packard Co.
Interactive Systems Corp.
Oryx Systems, Inc.
Pyramid Technology Corp.
Computer Consoles, Inc.
IBM/Interactive Systems
Masscomp Co.
Plexus Computers, Inc.
Bell
Bell
Bell
Teletronix, Inc.
Digital Equipment Corp.
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Data General Corp.
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Micronix
Oasis
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PRIX
QNX
Regulus
Uni-Del
Unos

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Cromemco, Inc.
Whitesmith, Ltd.
Morrow Designs, Inc.
Phase One Systems, Inc.
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Perq
Quantum Software
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departmental minis or superminis and mainframes, all running the same application software.

Changing strategies

These and other market forces are prompting hardware manufacturers to alter their competitive strategies in order to reap the benefits of con-

sumer demand for a standard, flexible, multiuser operating system.

Although still dwarfed in comparison with the total units shipped with Microsoft's MS-DOS (PC-DOS) and Digital Research, Inc.'s CP/M, Unix will be used by the majority of office workers and small businesses in this country by 1989. By the end of this

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decade, the evolution of the workstation market, multiple operating systems and networking capabilities may undermine the importance of operating systems. However, before that happens, the Unix market will undergo growth, shakeout, plateau and then decline, which is standard for every new market situation.

Virtually every major hardware vendor in the world is now considering some sort of Unix strategy.

Until now, it has been generally assumed that the controlling force in the Unix market would be AT&T. In December, AT&T announced System V.2 in an attempt to establish a standard Unix. This effort was prompted by the confusion surrounding the 23 or so "flavors" of Unix that are presently available. Accompanying the announcement of V.2 was the promise by AT&T to make licensing easier and less expensive. Of more importance was AT&T's commitment to actively market and support the Unix efforts of its hardware OEMs.

IBM immediately perceived the consequences of staying out of the

growing Unix market. Shortly after the AT&T announcement, IBM attempted to preempt the market by announcing PC-IX, a System III implementation for the IBM Personal Computer.

This announcement came shortly after a trial balloon announcement by the IBM Instruments Division of Xenix on the 8000. A third announcement came from IBM of Xenix on the 9003 and a marketing effort to position the 9003 as an office automation product.

On the third anniversary of the Personal Computer, IBM announced the PC/AT, thus filling the last major gap in the IBM Personal Computer product line and opening up the Unix market. We can now say that Unix has truly arrived as a standard.

System V's Influence

Unix is the standard multiuser operating system for 16- and 32-bit systems. Market demand will encourage Unix implementation across micro, mini and mainframe products by all major vendors. Virtually every major hardware vendor in the world is now considering some sort of Unix strategy, either for a single product or across an entire product line.

The deregulation and subsequent reorganization of AT&T is resulting in a more aggressive effort to promote System V as the standard Unix.

The adoption of Unix as an industry standard has been hampered by the lack of one standard Unix. Xenix dominates the low end of the market with more than 50,000 installations. System III and Version 7 are common

between \$25,000 and \$100,000, and proprietary versions can be found on many mainframes.

This proliferation of Unix types will end if AT&T is successful with plans to promote System V as the standard. AT&T is working closely with Digital Research, Inc. and several major chip manufacturers to standardize the product. However, this standardization process is hampered by the fact that standard Unix must be altered to make it attractive to end users with little technical experience. In order for System V to become

the true standard, AT&T must adopt a user interface that can be used across an entire product line, as well as record locking, virtual memory/paging facilities and more.

This year will see several major hardware vendors announcing a Unix product or line. Software developers, which have been rewriting applications in C, will then rush to offer software products to a growing market. The availability of these products will overcome the last obstacle to the establishment of Unix as a standard.

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And more coming.

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BREAKING OUT THE MARKET

Yates Ventures has divided the Unix market into seven price points: \$1,000 to \$4,000; \$4,000 to \$12,000; \$12,000 to \$25,000; \$25,000 to \$50,000; \$50,000 to \$100,000; \$100,000 to \$350,000; and \$350,000 and above. Research shows major differences between these price points in configuration requirements, Unix type and distribution channels.

In compiling information in these categories, assumptions were made:

- Only shipment rates of systems with licensed Unix were measured.
- All prices are end-user quantity one.

- Computer prices are for minimum configuration, including operating system, terminal and one year of maintenance.
- Price is held constant as capability and capacity of configurations increase.

- Dollar projections are weighted average (by price point) of units shipped multiplied by shipment rate projections.

There are more than 80 hardware vendors offering 125 different hardware products with Unix. Both of these figures are expected to grow by 30% this year. Inevitably, the market will begin to eliminate many vendors after the explosive growth rate for Unix-based hardware begins to slow by the middle of 1985. Many companies, founded in 1981-82 to provide Motorola, Inc. 68000 chip technology to an immature market, will find themselves unable to compete with major vendors such as IBM and AT&T for materials, shelf space, value-added reseller contracts and trained technical personnel. Bankruptcies, mergers and buyouts will be common in 1985.

The price/performance ratio of computer systems will decrease at a rate of about 4% during the next two years. (Customers will receive about four times the computing power for the same dollar cost.) After that time, the curve will level off for the next several years as software developers struggle to take advantage of these changes in hardware.

Chip sales

Motorola dominates chip sales in the Unix market. In the \$5,000 to \$12,000 price point, more than 80% of the units shipped were powered by MC68000 chips. In the next two price points, Motorola shares the market with Zilog, Inc. and, to a lesser extent, Intel Corp. Above \$50,000, proprietary CPUs dominate, but Motorola is making significant inroads with new manufacturers entering the market.

By 1985, National Semiconductor Corp. (16002) and Intel (286) will become popular as 32-bit systems begin to replace 8- and 16-bit systems. Motorola will continue to do well in this market with 68010 and 68020 CPUs. Zilog is presently doing well with its Z8000, and the Z80000 will be available early next year.

In under \$50,000 systems, 256K and 512K random-access memory (RAM) is very common.

Several vendors in these price points are offering systems with 128K RAM, but because of the requirements of the operating system,

these computers must be upgraded to run Unix effectively. During the next two years, even computers selling for less than \$25,000 will include 2M to 4M bytes of RAM.

Total installed units as of Jan. 1 are approximately 135,000, most of which (80,000) were shipped in 1983. Sales last year amounted to more than \$1.9 billion for computers, terminals, Unix and maintenance.

Unit shipments of Unix-based hardware will rise from 80,000 in 1983 to 925,000 in 1987. By the beginning of 1985, the total installed base will top 2.5 million. The majority of these systems will be in small businesses, vertical markets and Fortune 1000 companies. Most of the larger Unix systems will also have a second operating system running over or under Unix.

Key assumptions about the market and their impact on growth rates are:

- Unlicensed Unix will dominate the \$1,000 to \$4,000 price point.
- Retail sales of Unix systems will increase.

- IBM will continue to test the Unix market with several new product offerings to be announced by end of 1984.

- Start-up companies, with few exceptions, will never ship as many units as forecast, and many will leave the market by the end of 1985.

- Software development will allow Unix-to-MS-DOS communication by 1985.

- Fault-tolerant Unix will be available for process control by the fourth quarter of this year on some vendor's equipment.

- The popularity of Unix-based micros will create a demand for upward migration paths.

- Government/military sales will be an increasingly important vertical market.

SOFTWARE FOR SURVIVAL

Sales of Unix-based hardware approached \$2 billion in 1983. This figure will grow to almost \$12 billion by 1987, with strong support from the offerings of IBM, AT&T, Digital Equipment Corp., Hewlett-Packard Co. and other major vendors.

These vendors will enlarge and stabilize the Unix market and create opportunities for some of the smaller vendors.

However, the net result will be increased competition through the distribution channels, which will result in the elimination of undercapital-

ized companies from the marketplace.

Increasingly, hardware vendors will be unable to differentiate their products on the basis of hardware performance. Computers will become a commodity item, with the possible exception of products offered by IBM. This situation will force hardware vendors to find other methods of differentiating their products.

The most obvious differentiating factor will be software. Traditional Unix vendors like Albus Computer Systems, Inc. and Fortune Systems Corp. have been successful by offering their products as a multiuser solution made possible by Unix. However, their unique position in the market is quickly being usurped by new products running Unix offered by other vendors. As Unix becomes

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the standard multiuser operating system, vendors will be forced to offer application packages, especially word processing, to their customers.

Support is emerging as the second major differentiating factor. As the market shifts from technically trained programmers to relatively naive end users, support requirements change. Unfortunately, the support programs of most vendors have not

changed with the market. This situation is creating great opportunities for companies that can differentiate their products on the basis of dependable and reputable support programs.

A major trend is the emerging importance of vertical markets. By 1987, a full 60% of all Unix-based hardware will be sold into vertical markets. This is a projected \$7 billion market opportunity for hardware

The need for flexibility is one of the major reasons for the growing popularity of System V at the expense of BSD 4.1.

vendors and system integrators offering turnkey solutions to business problems.

The present fluid situation in vertical markets is difficult for vendors to exploit and confusing for end users trying to make purchase decisions. System integrators were born from a need by minicomputer vendors to reach a market that could not be addressed profitably through direct sales. These remarketers quickly found that they could differentiate their products through the use of vertical market software. Since the late 1970s, when most system integrator companies were founded, hundreds of small software developers have entered vertical markets with their products. Today, there are no fewer than 10,000 vertical market packages available.

This situation makes it virtually impossible for potential customers to make informed purchase decisions. The result of this confusion is that potential customers are postponing those decisions. The future for vertical markets is with expert salespeople, selling turnkey solutions, with the ability and

reputation to provide dependable support.

There are two main segments which offer substantial opportunities for vendors. The first is the scientific market above \$100,000. This area has traditionally been dominated by DEC and its VAX and PDP-11 families. A major reason for this dominance has been the fact that the fastest and easiest way of getting Berkeley 4.1 Unix source code was by purchasing a VAX. However, this situation has changed dramatically as AT&T has begun promoting System V as the industry standard. Not only is source code available now for a wide variety of computers, but BSD 4.1 is beginning to lose favor as the Unix version of choice at this price point.

There is a general trend at this price point to utilize computing power for more general purposes. Hardware that was purchased primarily for scientific and engineering applications is now being shifted into more general business use. Data processing managers are beginning to consolidate the computing power of the company into a

central structure. Consequently, VP managers are looking for operating systems with more general applications. This need for flexibility is one of the major reasons for the growing popularity of Unix and a major reason for the growing popularity of System V at the expense of BSD 4.1.

These changes in the market are fueling a growing trend toward multiple operating systems. A notable example is the 90x computer from Pyramid Technologies. The 90x comes with both BSD 4.2 and System V. The operating systems can be configured by the user at any time. This product is an attempt by Pyramid to fill the gap between the business and scientific market, without having to sacrifice either. Several other companies are also experimenting with multiple operating systems, using either switches or windows to accommodate the second operating system. The Tandy Model 16, best-seller in the Unix market, accommodates both Xenix and TMS-DOS.

The second major opportunity exists for business applications in the \$12,000 to \$25,000 price point. Currently, more than 25 vendors offer 40 to 50 hardware products in this market segment. Many of these manufacturers are offering products in anticipation of IBM entering and expanding this market. The Personal Computer AT's announcement, however, has put their products, and the IBM stamp of approval will expand their market.

Research clearly shows that there is a growing pent-up demand for multiuser capabilities at the \$12,000 to \$25,000 price point. Potential customers with some experience using computers have realized the advantages of multiuser, multitasking capabilities. They may already own a business or home computer and are looking to upgrade. However, these potential customers are not willing to take a chance with a product from a manufacturer they know nothing about. Consequently, they are postponing their purchase until they can buy something "safe" and dependable. IBM has answered their need with Xenix on the AT and will probably offer additional products targeted at office and lab, with Unix as a major operating system.

Joan Yates is founder and president of Yates Ventures, Inc., a market research firm based in Los Altos, Calif. She is the author of the Business Guide to Unix Systems, the Business Guide to the Xenix System, the Programmer's Guide to the Xenix System and the Programmer's Guide to the Xenix System.



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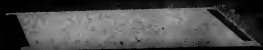
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the kind of technology needed in an operating system for 16-bit processors and beyond. Unix was portable, encouraged the development of portable applications and offered advanced system facilities and true multiuser capability. It also provided a superior software development environment. These features were recognized as necessary to the development of applications which would enable micros to compete in mini-dominated markets.

So much went so wrong so fast in the development of a multiuser systems market that it is not possible to trace all the events or follow any chronological order. In order of importance, the first problem was the entry of IBM into the microcomputer fray. The market had enjoyed what was, by comparison, orderly growth and development limited by the pro-

duction and marketing resources of the relatively small players in the game. IBM infused a production and marketing potential that upset the delicate allocation of scarce development resources for both software and hardware.

Most software houses shifted to producing software to support the new "IBM market" — which was, of course, a single-user market based on the then-new MS-DOS operating system. Hardware manufacturers immediately saw that IBM was defining a new class of machine that would open entirely new markets for computers and so shifted engineering and manufacturing resources to allow them to move in on the opportunity.

The second problem was the time it took hardware manufacturers to develop machines that were adequate to run Unix. The mini market

discovered through many years of design trial and error that multiuser time-sharing systems really needed specialized hardware technology if they were to operate reliably and efficiently. Micro builders had never been faced with this need.

Companies that were accustomed to producing entirely new designs within a year found themselves without products two years after project inception; and once they finally had a product that worked well enough, they found it necessary to start new designs immediately, incorporating all they had learned developing their original computers. This situation drained the resources of both hardware and software developers. Third-party and in-house software developers had to try to keep pace with (and find the deficiencies in) what the hardware manufacturers

were coming up with — through iteration and iteration.

As a result, the resources available to work on multiuser projects weren't sufficient to get products out anywhere near when the market expected, and the disparity in size and emphasis between the single-user and multiuser markets continued to grow.

The third problem was the choice of the Zilog, Inc. 28000 as the initial engine by most of the pioneers of systems based on Unix — and that chip's eventual demise as a major element in the general-purpose, 16-bit microcomputer market.

The choice of the 28000 was logical. As a processor, it most closely emulated the architecture of the Digital Equipment Corp. PDP-11 from which Unix was being ported. The Motorola, Inc. 68000 was seen as perhaps the best of the three chips available for running a system based on Unix because it offered capabilities

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The "Unix market" is a bit of a misnomer.

even beyond the PDP-11. However, the part wasn't ready for mass application, and there was no software support — even in the way of development tools.

But the 28000 itself took three critical blows: IBM's choice of the 8086-compatible 8085 processor, which diverted software development away from the 28000; the problems faced by the engineers in getting a 28000-based system to market, which allowed the 68000 to catch up; and the failure of Zilog itself to produce the needed support chips in a timely fashion, which would have gotten 28000-based systems to market much sooner.

Again, the net impact of this disaster was to waste precious hardware and software engineering resources on efforts that resulted in what were marginally successful products at best — certainly none that created anything resembling a multiuser market of critical mass.

Despite the difficulties, the advanced microprocessor, 16-bit multiuser systems and the dedicated Unix pioneers (Alto Computer Systems, Onyx Systems, Inc., Zilog, Plexus Computers, Inc., Fortune Systems Corp.) captured roughly 10% of the total market for desktop or larger microcomputer systems for business. This market segment represented the best chance that small microcomputer companies and their vertical application-oriented, value-added resellers and distributors had to create the kind of unique added value that would assure their long-term viability. This segment of the market also supported higher margins on hardware and software, allowing the smaller companies to compete profitably even though they didn't have the economies of scale of the larger companies competing in the much larger single-user market.

The "Unix market" is a bit of a misnomer. There are more than two dozen different operating system products based on Unix technology that populate what is termed, the



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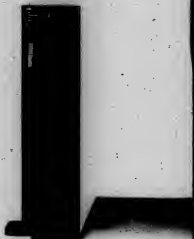
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"Unix" market." Licensed Unix-based products like Xenix, Unipix, Zeus, Pico, Vexis and Genix all have their differences.

Even so-called "standard" Unix products based on the same version differ somewhat in features, documentation and support. In fact, they are not, strictly speaking, compatible systems, since the process of porting Unix from the VAX to a micro and the process of making a commercial microcom-

puter-based product out of those VAX ports create several opportunities to introduce incompatibilities. Add in the lack of a standard medium and format for software distribution, and even the 10% market share (assuming Unix had it all) isn't really a homogeneous base of systems for software marketing.

Enter AT&T

Now that AT&T is pouring millions into the Unix market

with products of its own, what has been the impact on applications availability?

Precious little, really. Thus far, AT&T's advertising has aroused interest and curiosity, but the uninitiated are quick to discover that the Unix market has a way to go yet before it "looks" like the other popular segments of the small computer market. Insiders are encouraged by the exposure Unix is getting. And with AT&T active, there's little likelihood that

Unix will go away. But thus far, no real difference has been made. AT&T is developing two (or more) programs to stimulate software development.

Actually, there are a lot of excellent applications available for one version of Unix or another if you know where to look and if you settle on the applications you need before locking yourself into a particular Unix system.

Most companies who find

themselves purchasing a system that runs a version of Unix actually were "found" by the system vendor. These companies either retained a consultant to find a solution to their computing problems or they have been contacted by a representative of some vertical applications package that happens to run on some sort of Unix system. Because most of the 80,000 to 100,000 Unix-based business systems have been sold this way rather than through mass-market advertising or retail storefronts, the visibility of this software remains very low. Consequently, the perception is that there is very little software for Unix.

Profit potential

The pioneers of Unix attempted to distribute their products via retail channels, though not exclusively. These efforts were largely unsuccessful, since Unix had not yet been domesticated enough to be successful in these relatively unsophisticated marketing channels. The notable exceptions were chains that specialized in providing sophisticated business solutions — such as the Control Data Business Centives and the Microgate computer stores.

While these outlets did not set any sales records, they demonstrated that Unix-based systems could be profitable. But the extra investment they made was one that few others were willing to make. Some chains were so disappointed by initial efforts with Unix-based systems that they are reluctant now to give them a second chance, even though far more refined versions exist.

Recognizing that only through a more visible presence could any Unix-based system be popularly accepted, Microsoft launched an effort in 1982 to produce a version of its Xenix that could be successfully marketed through retail channels. The theory was that by actually going through the drill of producing a retail version (all-new documentation, retail packaging, new user-oriented facilities), the company could provide a superior product to its OEM customers (such as Tandy Corp., the first manufacturer to license this advanced version of Xenix for its Model 16).

Several other Unix suppliers followed suit. Now, if one looks hard enough, one can find Xenix for the IBM Personal Computer and Apple Computer, Inc. Lisa (distributed and supported by the Santa Cruz Operation), Unipix for Lisa (from Unisoft Systems Corp.), Vexis for the IBM Personal Computer (from Ventracom, Inc.) and Coherent (a Unix look-alike from Mark Williams).

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UNIX TO UNIX NETWORKS

Unix and networking have been close associates for much of the operating system's history. Given Unix's origins within AT&T, it is not surprising that support for file transfers and remote system access across the public network appeared in fairly early versions.

The prominent early role of Unix in universities and research labs, many of them connected through the Defense Department's Advanced Research Projects Agency Network (Arpanet), encouraged further development of Unix communications software. Today, a well-established network of Unix developers and "gurus" communicates through a mail system that carries thousands of messages a day.

Availability of Unix on low-cost microcomputer systems and the falling cost of local-area network technology combined to create a new focus for Unix networking over the last several years. Unix-based networks are emerging as an effective way to interconnect several low-cost Unix systems within a facility. From an early role connecting development systems, these net-

works have moved to commercial stature, linking micros in end-user installations. Several of the leading Unix-based system manufacturers now offer local-area networking products.

The networking software available today is characterized by diversity rather than standardization. Some software packages offer a networking base on which the user can construct his own network applications. Others focus on end-user networking utilities. Some approaches stress vendor independence and even operating system independence. Others emphasize ease of use and performance.

Some of the earliest work adapting Unix to local-area networks took place at the University of California at Berkeley, famous for its virtual memory implementation of Unix. Berkeley networking support was outlined in 1981 and implemented in the 4.2 BSD version, distributed this year. Sun Microsystems, Inc. implemented Berkeley networking commercially in its line of Unix-based workstations.

Berkeley networking focuses on interprocess communications services. These services allow an ex-

cuting Unix program (a process) to communicate interactively with another process executing on another system in the local-area network. Two types of communications are supported: datagrams, in which a one-time "message" is sent, and virtual circuits, in which a semipermanent connection between the processes is established for dialogue. The interprocess communications services form a networking foundation for use in implementing a user's own applications.

The Berkeley services are implemented by extending the Unix kernel with new system calls for interprocess communications support (see Figure 1 on Page 52). This approach offers the performance advantage of tightly integrated operating system code for networking. Its disadvantage is that networking applications must be specifically written to use the Berkeley version of Unix and will not work on other versions. In fact, AT&T's System V includes a different, incompatible scheme for interprocess communications within a single Unix system.

Another Unix networking package based on interprocess communications is Fuslon, from Network

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Research Corp. Like the Berkeley software, Fusion offers a "socket driver" that allows application-level programs executing on different systems in an Ethernet network to communicate.

Fusion also includes a set of networking utilities that were designed for the end user rather than the programmer. The utilities support file transfer, network mail and remote login, as well as various network ad-

ministration functions.

Unlike the Berkeley approach, Fusion works with an unmodified Unix kernel. Low-level network services are implemented within an Ethernet driver, which can be integrated into different Unix versions as easily as any Unix device drivers. User-level network functions are implemented in a collection of utilities that execute as ordinary Unix applications programs.

The advantage of this architecture is vendor independence. Fusion not only works with different versions of Unix (Version 7, System III, System V, Berkeley and so on), but it is also available for use with Digital Equipment Corp.'s VAX/VMS and Microsoft Corp.'s MS-DOS. Fusion can thus be used to connect very different systems on a single local-area network.

These advantages come at the expense of a less elegant programmer's interface to the interprocess communications services and, presum-

ably, some performance loss.

Vendor-independent approaches that rely on file transfer utilities also have a drawback in their lack of user transparency. A secretary familiar with a word processing package on a local system, for example, must be trained to use new network commands and file transfer utilities to access documents on a remote system. Further, while copying files to a local system may be adequate for some applications, it is completely unsatisfactory for others. An example is shared access to an on-line inven-

tory data base from multiple systems in a local-area network.

Several software developers have specifically addressed the problem of shared, interactive file access across a Unix local network by creating a distributed Unix file system on the network. The system behind the distributed file system concept is simple — extend the hierarchical file system on each local machine on the net to somehow include the file hierarchies on other systems in the network.

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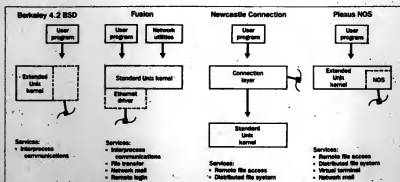


Figure 1. Architectures, capabilities of several Unix/local-area network solutions.

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This benchmark is a UNIX system that is available to the UNIX community. It's a system that can be used to compare your own performance to the benchmark. It's a system that can be used to compare your own performance to the benchmark.

a distributed file system is to introduce another layer of hierarchy above the individual system (see Figure 2 on Page 54). The top level (or "root") of each individual file system in the network thus becomes a sub-directory of a single, networkwide root. To locate files in a remote system, the user simply specifies a path up through the top of the file hierarchy on his local system and then down into the hierarchy on the remote system.

This distributed file system scheme is implemented in the Worknet product from Allos Computer Systems, Inc. and in the Newcastle Connection, developed at the University of Newcastle in the UK and now being marketed commercially. The Newcastle Connection supports interactive remote file access by interposing a connection layer between user programs and the Unix kernel. This layer traps requests for access to remote files and passes them across the network for completion on the remote system (see Figure 1).

While this implementation offers independence from any particular Unix version, it suffers a performance penalty when compared with modified-kernel approaches.

A different distributed file system approach is offered in the Network Operating System (NOS) of Plexus Computers, Inc. for its line of Unix-based supermicros. NOS gives users access to remote files in a local-area network by allowing any arbitrary directory on a remote system to be "attached" at any point in the local system's file hierarchy. If customer files on a system in an accounting department are to be shared with users on the marketing department's system, those files (and only those files) can be "attached" into the marketing file system (see Figure 3 on Page 54).

To users of the marketing system, the customer files appear exactly as if they were present actually on the marketing system; access is completely transparent. Veteran Unix users will recognize this scheme as a straightforward extension of the "mount/unmount" approach used by

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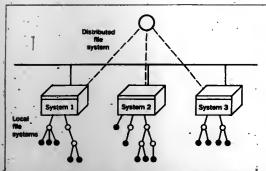


Figure 2. The Newcastle Connection distributed file system. The solid circles represent files and the blank circles directories.

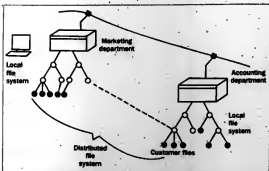
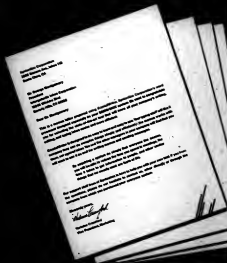


Figure 3. The Plexus NOS distributed file system, showing transparent sharing of customer files on a local-area network.

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SYNTACTICS

Unix to accommodate multiple local disk drives.

The major advantage of the Plexus approach is its transparency. Users of remote files do not even need to know on which remote system the files are located; all that matters is that they are logically a part of the local hierarchy. In fact, the network administrator can introduce new systems in the network and move direc-

Vendors will be working toward each other, incorporating competitors' best ideas.

tories from system to system simply by changing the network "attachments," with no impact on user programs or utilities. NOS also supports full record locking and security, so interactive access to remote data bases is possible.

NOS is implemented as an extension to the Unix kernel. Remote file I/O is performed through the standard Unix read/write/open/close calls, which are transparently mapped to other systems by NOS.

The advantages of this approach are its transparency and performance. Disadvantages include its vendor-dependent restriction to the Plexus NOS kernel and the absence of user-level interprocess communications capability.

The offerings of the major players, AT&T and IBM, are largely unknown. AT&T's 3BNet is in its early stages, with only primitive software support available. IBM unveiled its cabling scheme but little about its local-area network software and only glimpses of its Unix strategy.

The level of ongoing development in Unix-based local-area network software is extremely high. Vendors will be working toward each other, incorporating the best ideas and features of their competitors' products. Yet standardization among approaches and vendors is far from realization.

Jim Graff is marketing director for Plexus Computers, Inc. in Santa Clara, Calif.

BEST BOOKS

By Jim Joyce

Every month, it seems, two or three new Unix-related publications go to press. The question asked at the Independent Unix Bookstore is no longer "Is there anything about Unix?" but "What is the best book for me?"

Here is a guide to the best books for managers, programmers, non-programmers and more advanced Unix users. Specifically omitted for space reasons are the growing

number of books on C, the language in which 98% of Unix is written. The Independent Unix Bookstore's catalog contains annotations for books about both Unix systems and C.

For managers. Managers, marketing and technical people who want to know something about Unix but do not need detailed knowledge will find Paul Weinberg and James R. Groff's *Understand-*

ing Unix: A Conceptual Guide (Que Corp., 225 pp., \$17.95 paper) the right selection. This book discusses how Unix fits into the world of computing, what its major features and benefits are and how the system is structured.

As an example of just how astute the authors are, they accurately conjectured in 1983 that Interactive Systems Corp. was at work on VM/IX, the IBM mainframe port of





Unix. VM/IX was released in mid-July.

Technical discussions of commands and shell scripts are included in Weinberg and Groff, but not at the level of detail to be found in a book for programmers. The subtitle is "A Conceptual Guide," and that is what the book delivers quite well.

Programmers learning Unix. Three books tie for best choice for this audience, depending on how experienced in programming the reader is.

For highly experienced programmers who may already know something about Unix from trade press articles, Steve Bourne's *The Unix System* (Addison-Wesley, 349 pp., \$16.95 paper) is the book to read. Bourne wrote the standard shell, the command interpreter corresponding to job control language on other sys-

tems. Those who thread their way through the tennis ladder example in this book will surely know the power of Unix utilities and the shell as a programming language.

Those needing a more introductory book have a genuine choice between Henry McGilton and Rachel Morgan's *Introducing the Unix System* (McGraw-Hill, 566 pp., \$19.95 paper) and Mark Sobell's *A Practical Guide to the Unix System* (Benjamin/Cummings, 425 pp., \$21.95 paper).

Both are carefully crafted, with clear examples showing how to make use of Unix's power. Sobell's book shows what can be done with a thoughtful use of visual aids to help readers grasp concepts. McGilton and Morgan include a chapter on system administration for readers who have one of the many micro-based Unix systems now available.

Unix for nonprogrammers. Just which book is the best for a nonprogrammer depends on the meaning of the term and what the reader wishes to learn.

A senior systems analyst may well find Groff and Weinberg's book quite satisfactory as a guide to the scope of Unix's power.

Selective reading of McGilton and Morgan or Sobell can provide a nonprogrammer with a working knowledge of the system's word processing capabilities.

Nonprogrammers in a Berkeley Unix environment may find *Unix Primer Plus* by Mitchell Waite, Donald Martin and Stephen Prata (Sams & Co., 414 pp., \$19.95 paper) a pleasant way to learn the system. However, the Berkeley 4.2 Unix emphasis will be frustrating to those on systems that do not include Berkeley en-

hancements.

Intermediate Unix. Without a doubt, *The Unix Programming Environment* (Prentice-Hall, 357 pp., \$19.95 paper) by Brian Kernighan and Rob Pike is a must-read book for anyone seriously interested in using Unix effectively. There is a book of philosophy disguised as a technical book. It is technical, to be sure, but its strength lies in the thinking they do about the Unix programming environment.

The script for the "pick" utility and the discussion of it are worth the price of the book alone. Programmers who add features to programs will want to study the discussion carefully to see a very different approach that is a genuine increase in functionality.

Unix internals. Unix source code, one soon finds, is protected by trade secrets, and anyone who has had access to source code is bound by signed agreement not to reveal the code to those who have not signed such a nondisclosure agreement.

Thus, Douglas Comer's *Operating System Design: the Xinu Approach* (Prentice-Hall, 474 pp., \$29.95 hard-bound) cannot, of course, be Unix source in book form. That Xinu is Unix spelled backward is provocative enough, though.

The book, at the bottom line, is about operating system design, and Xinu is a Unix-like operating system. Someone with access to Unix source code could also use the book as a helpful companion for reading the code.

Guides to software and systems. Three guides are available to help readers determine what Unix offers and what software and systems are available.

Bill Freiboth's *The Unix Guide* (Pacific Micro Tech, 118 pp., \$24.95 paper) is designed "to help readers determine what Unix offers." Unix Version 7, System III, System V, 4.x Berkeley Unix and Unixoft's Unipix are compared in discussion and table form. The guide is not for technicians, because they do not need it. It is for those who want to know about Unix version differences.

The */usr/group Unix Catalog* (*/usr/group*, 458 pp., \$30), compiled by August Mohr and now in its third edition, contains summaries by 276 companies of 787 Unix-related products and services. Although it tries to be complete, the catalog depends on companies' timeliness in contributing their entries. Nonetheless, it is a valuable compendium of information about Unix in a commercial environment.

Ray Jones' *The Unix Applications Software Directory* (Oscar Publishing, 198 pp., \$50 paper) describes nearly 400 applications packages from benchmark suites to Cobol compilers, accounting packages and graphics software. It should be used with the */usr/group* catalog for best results in reaching companies selling software. At the back of the directory is the promise of a hardware directory, a much needed addition to the body of books on Unix.

Jim Joyce founded the Independent Unix Bookstore, 580 West Street, San Francisco, Calif. 94117. He is also president of *Qualitative Technical Seminars*, a firm specializing in Unix and C training, documentation and consulting services.

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THE USER EXPERIENCE



WHAT UNIX CAN DO

Go inside Bell Labs to see how remote voice access, digital signatures and network modeling work.

Page 60



UNIX RUNS THE OFFICE

The daily operation of a financial services subsidiary depends on terminals as much as telephones. These terminals run System V.

Page 63



UNIX GATEWAY

The Air Force Logistics Command uses an Intelligent Gateway Processor as a window to logistics information.

Page 67



Bell Labs: testing ground for Unix

WHAT UNIX CAN DO

(Beverly Dyer, a programmer with AT&T Bell Laboratories in Short Hills, N.J., describes the digital signature project.)

One of the current limitations of electronic messaging systems is the inability to sign a message by hand. A signature provides a legally acceptable guarantee that the owner has authorized its contents. In 1983, we began to explore this problem at AT&T Bell Laboratories, and our efforts resulted in the digital signature project.

The scheme we implemented uses the RSA public-key encryption algo-

riithm (named for its inventors, Rivest, Shamir and Adelman), in which each user is assigned both a public and a secret key. The signature technique works as follows:

1. A checksum is computed on the message to be signed. This checksum must be fairly unique to the message, such that it is very difficult to generate a different message that would produce the same checksum (preventing the possibility of someone intercepting the message and changing a salary figure from \$10,000 to \$100,000).
2. The checksum is encrypted to form the signature, using the authorizer's secret key.
3. The signature is sent, along with the message, to the verifier.
4. The verifier decrypts the signature using the authorizer's publicly known key, arriving at a number which, if correct, is the same as the original checksum. The checksum procedure is repeated on the received message, and if the two numbers are equal, the message is the same as that signed by the authorizer.

There are a number of reasons the Unix operating system was ideal for developing this project. It provides flexibility with both high- and low-level functionality.

Pieces of software used separately, in combination and as a whole needed very little modification for different applications or different processors. Prototyping the system through several stages was quick and simple. The signature procedures were written before being interfaced to our standard electronic mail system, for example, and no changes to the mail system were necessary.

The signature code also makes use of a package of arbitrary-precision math routines that were developed on a different processor and ported to our machine with no changes. High- and low-level commands can be accessed with very little interfacing work from the programmer.

The Unix system also offers significant advantages for deployment and use of digital signature applications within Bell Labs.

The system is widely used on a variety of processors from several different vendors. The common environment allows the digital signature applications to be deployed across these various systems with little or no conversion effort, making them accessible to a large population.

Most of the computation involved in this set of programs is spent performing arithmetic functions on very large numbers. Raising a 100-digit decimal number to the power of a number the same size requires the efficiency of assembly language. The C language allows code that is nearly as efficient as assembly language, without sacrificing portability.

Digital signatures are intended for use by a large population, and the user interface was designed to be simple. The multiprocessing capability of the Unix system allows much of the computation to be done "behind the user's back," so to speak. In our case, this background processing is invoked directly by the digital signature package via statements in the shell command language, requiring no special programming of the parts run in the background.

Commands in the shell program can "pipe" input and output to and from the user, results of other shell commands and C programs,

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UNIX RUNS THE OFFICE

(Michael Reuter, assistant vice-president and director of computer services at Commercial Union Capital Corp. in New York, tells how Unix is faring after eight years in the company.)

Unix is not just for programmers. Commercial Union Capital Corp. has used Unix for its internal business data processing needs since 1976. Formerly Commercial Union Leasing Corp., Commercial Union Capital Corp. is the financial services subsidiary of Commercial Union Insurance Co. and is known in the world of corporate finance for its specialization in big-ticket leveraged leasing.

Currently, the company runs the latest AT&T release, System V, on a Digital Equipment Corp. VAX-11/780.

The VAX is configured with a floating-point accelerator, 2M bytes of main memory, three 176M-byte removable-media disk drives, an 800/1,600 bit/in. tape drive and 48 asynchronous communications ports. Each of the 50 employees has a hardwired 9,600 bit/sec terminal on his desk, and all use Unix directly with varying degrees of sophistication.

The secretaries use the standard Unix "nroff" package and the "vi" full-screen editor for word processing. Files containing nroff formatting

commands are created or modified using vi and are then processed by the nroff program.

The finished documents are printed at either a high-speed laser printer (for draft versions) using the "lp" spooler package or on a letter-quality printer (for final copy). Spelling errors can be found using the standard "spell" command, and changes to successive drafts of a document can be indicated by a local version of the Unix "diffmk" program.

"What-you-see-is-what-you-get" full-screen text editors such as XED, marketed by Computer Methods Ltd., and LEX, from Uniprise Software, Inc., provide automatic fill and right justification of text, sophisticated table processing and form letter generation.

These systems are currently available under Unix, are more elegant ap-

All of the 30 employees use Unix directly, with varying degrees of sophistication.

proaches to word/document processing and will eventually be integrated into our Unix environment.

Secretaries are also well versed in the Unix file manipulation commands to create, move and remove files and directories. In addition, they make use of the hierarchical na-

ture of the Unix file system to group personal correspondence, proposals and other materials logically.

The entire office uses the standard Unix "mail" and "write" commands to send short interoffice notes and to hold terminal-to-terminal interactive conversations. A full-screen-oriented application was written locally around those two commands to provide our receptionist with a convenient technique for notifying the staff of incoming phone calls and to record phone messages. Another local application makes use of the "at" command to send mail messages at a future date.

Also used extensively by the entire office are locally written programs to keep track of lunch orders and to indicate who is out of the office for vacation, illness or business trips. A local variation of the "calen-

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VAX-11/780



VAX-11/785

can link multiple processors together and manage them as a single unit in a VAXcluster system. This capability, which is unique in the industry, enhances data integrity, increases system availability, and does it all with complete user transparency. Moreover, it permits the resources of a single facility to be shared throughout your organization, and lets you keep pace with expanding needs through incremental system growth. As many as 16 processors and storage servers can be combined in a single VAXcluster system,

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expand up or distribute down as your needs dictate. And you won't have to retrain, reprogram, restructure files or abandon the system you began with.

The VAX computer family's unmatched applications versatility means that every area of your operations - from the factory floor to the engineering lab to the executive office - can take advantage of the unequalled value of VAX systems. The VAX Software Source Book lists many of the thousands of applications developed and supported by Digital and independent ven-

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dar" command helps track personal appointments.

The financial staff uses the Multiplan spreadsheet program for various analytic purposes. (Multiplan was developed by Microsoft Corp. and ported to the VAX Unix V system by the Santa Cruz Operation.) The ease of use of Multiplan allows these noncomputer professionals to create and manipulate spreadsheet models without the aid of the programming staff.

Because of the complexity of leveraged leasing, a large software model was written locally to provide the financial staff with the economic analysis and accounting information necessary to structure lease transactions.

The reports produced by this model, bid proposals and other documents are made available to our co-

Experience has shown us that the best way to use the Unix operating system is to avoid modifying it.

investors who dial into our system for immediate access to time-critical information. Unix provides a technique for replacing the standard user interface, the shell, with a locally written program. This technique allows us to limit our co-investors to accessing just the information that is for their eyes.

To keep track of co-investors and match potential investors with upcoming deals, a data base of pertinent information is maintained on corpo-

rations. Local front-end applications provide menu-driven, screen-oriented interfaces to the data base to retrieve information selectively, based on company name or deal characteristics, and to modify or add to the data base.

The data base and associated applications are implemented using Relational Technology, Inc.'s Ingres data base management system. Ingres was developed from a research prototype at the University of Cal-

ifornia at Berkeley and is provided with the current standard Berkeley system, BSD 4.2. Local modifications were necessary to run Ingres on AT&T Unix System V.

Training of newly hired secretaries and financial staff is now being handled by User Training Corp.'s audio-digital "Unix System Tutorials." These courses provide excellent introductions that are truly geared for computer novices and not for programmers learning a new system. The courses contain information on basic concepts, the file system, the vi editor and the Multiplan spreadsheet program. (Unfortunately, missing is a course in nroff.)

The student listens to the presentation on headphones connected to a special cassette deck that is also connected to his terminal. The terminal screen is used as a blackboard to emphasize topics and to show typical system responses. The student may at any time stop the cassette and put his terminal on-line to practice a new topic directly on our system. This audio-digital medium is particularly effective in teaching the use of full-screen applications such as vi and Multiplan.

Programming tools

Of course, there are many Unix tools available to the programming staff. All local programs are written in the C programming language or the Unix command interpreter language known as the shell language. Most C programs are written to be full-screen-oriented using the "curses" library of terminal cursor movement functions.

The "termcap" library of terminal capabilities and escape sequences allows the curses functions and, therefore, our local applications, to be terminal-independent.

The various releases of our major applications are maintained under the Unix source code control system, SCCS. Program debugging is accomplished using the symbolic debugger "adb" and also by the use of a new C compiler called Satec, developed by Catalystix Corp. The debugger adb provides monitoring of running programs and analysis of the core files produced by software faults. Satec provides runtime checks on array subscripts, pointer validity and function argument lists.

The Unix "xref" command provides cross-referencing of all C variable names with their uses in a program and is valuable during major program modifications.

System administration tools available under standard Unix and used by Commercial Union Capital Corp. include the "acct" accounting package for monitoring of system usage by account, port number and command name. Also, the system activity package "sa" provides very detailed CPU and disk usage for fine-tuning Unix.

Experience has shown us that the best way to use the Unix operating system is to avoid modifying it. Having the Unix source code available on-line is a temptation to clever programmers. However, part of the beauty of the newer Unix releases is that they don't require systems programmers to modify or maintain them. Unix allows the programming staff to spend its time writing applications and harnessing the power of the available tools to facilitate the company's business.



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UNIX GATEWAY

(Frederick Sutterlin directs the Logistics Networking Systems Program Office at the Logistics Management Systems Center of Wright-Patterson Air Force Base in Ohio. He reports on an intelligent gateway system, based on Berkeley 4.3 Unix, with Lawrence Livermore Labs enhancements, that will tie all of the Logistics Command's information systems.)

Intelligent gateway? "I thought a gateway interfaced two networks; you might say. Well, that's true, but the Intelligent Gateway Processor (IGP) is much more than an interface between two networks. It does provide a user — whether on a local-area network, multiplexer or dial-up modem — with the ability to connect to local-area networks, public data networks, the Defense Data Network (DDN) and others.

But the IGP provides much more service than just connectivity. It is a user's window to the world of information processing.

For the Air Force Logistics Command (AFLC), it is going to be a window to logistics information and a way to avoid the catastrophe of 10 terminals on a user's desk.

The AFLC has more than 600 Logistics Management Systems (LMS), many now being modernized. Competitive acquisition of these systems brings a mix of architecture and protocols that makes full-scale interoperability a real problem.

The challenge is to figure out a way to provide interoperability for these new systems without disrupting the old ones and to maintain current state-of-the-art capability while still providing competitive procurement.

Unix to the rescue! Thanks to the modifications that Lawrence Livermore National Laboratories and the University of California at Berkeley made to AT&T's Unix, there is an operating system that can help AFLC provide this interoperability for its users. Based on the Technology Information System developed by Livermore Labs, the software is the foundation for AFLC's Intelligent Gateway Processor.

The processors will allow a user to access hundreds of different data systems throughout the world by virtue of sophisticated Network Access Machine software developed at Livermore Labs.

The self-guided software will provide the user at any asynchronous terminal with a window to AFLC's information systems.

The only requirement for these systems is that they provide asynchronous communications capability, including access to local-area networks and dial-up facilities. This approach is necessary to avoid protocol conversion to the extent possible. Besides, with the many information systems currently under development, each user could wind up with many terminals on his desk unless something is done. So the asynchronous Ascl standard for terminal-host connections is being adopted.

There are alternatives to the multiple-terminal issue, but multifunctional terminals are not the answer

Fred Sutterlin is planning a Unix-based "window" to logistics information.

for all requirements because you must have a very smart terminal to accommodate all the different protocols required, unless you adopt an asynchronous communications standard. In that case, multifunctional terminals are necessary only when talking to synchronous systems, and the target system does not have an asynchronous communications capability.

All asynchronous terminals are not the same, of course. Berkeley Unix incorporates "termcap" software, which defines the cursor addressing characteristics of any asynchronous terminal. When the user logs on to the system, he is prompted for his terminal type, and the terminal characteristics for that terminal are associated with his particular login environment for that session. In that way, a user is never required to use a particular terminal. He may use a variety of briefcase terminals for access to data systems from remote locations, or he may use any of

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hundreds of different desktop asynchronous terminals.

Different terminal characteristics may be added in a matter of a few minutes as new terminals are acquired.

The IGP will provide the user with very powerful connect routines, which can be programmed to log on the user at the designated host. These routines are password protected, of course, but do give a user the freedom to extract information from a variety of systems without having to know the ID and password for each of them. Permission for access to these systems is granted by the system administrator and coordinated with the data base administrator of the other system.

Connected by the Defense Data Network, these IGP's will be located around the country at each of our Air

User communities will have the ability to tailor their own gateway processors to their unique applications.

Logistics Centers (ALC) and will each serve hundreds of logistics managers, most of whom have primarily worked from large listings of logistics data to do their jobs. With the advent of distributed on-line systems, AFLC is again becoming a major force in state-of-the-art technology; but as in any new way of doing things, the end users need on-line, friendly assistance to take advantage of this new capability. The IGP's will provide this assistance, helping users to access a

variety of data from a variety of systems.

In addition, these IGP's will be functionally tailored to that user community such that a maintenance organization may have software tools specifically designed for maintenance functions, and a budget organization could have a completely different set of tools for its particular needs.

These tools include time/management packages, electronic spread-

sheets, personal calendar programs and graphics packages. Individual user communities will have the ability to tailor their own IGP's to their unique applications using the wide variety of programming tools available with Unix, such as C language, Fortran, Pascal and shells.

The IGP also provides, therefore, an Office Information System (OIS) for each user community in addition to the powerful connectivity capability. With this approach, AFLC can save many millions of dollars over the next few years by avoiding the pitfalls of acquiring a variety of vendor proprietary software for office automation applications, little of which interfaces with the other. The IGP software (basically Berkeley 4.2 with Livermore Labs enhancements) is the foundation for a variety of OIS applications and will be the thread that ties all of AFLC's information systems together.

Why Unix? In our search for a portable operating system to provide command, control and communications capability for the European Distribution System (a Federal Ex-

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The amount of data created for our managers will be awesome.

press type of concept for our air forces in Europe), we discovered that Livermore Labs Technology Information System Office had already developed many of the connectivity features for which we were searching. As Livermore Labs is a government-owned and contractor-operated facility, the software is available to certain government organizations, provided they have the proper Unix license from Bell Labs and Berkeley and a contract with the Department of Energy for Livermore Labs support.

The director of the program office responsible for the European Distribution System made the decision to adopt the Livermore Unix-based operating system. Its communications features and powerful electronic mail capability matched the needs. From this beginning, the Livermore/AFLC relationship developed, and the IGP concept was born.

The Air Force Logistics Command will modernize or create hundreds of information systems over the next 10 years, and the amount of data created for our managers will be awesome. The IGP will give these managers the necessary help in locating and connecting to the information required for AFLC to support the Air Force mission.

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**JACK SCANLON:
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major upgrades. While I would not like to commit to announcements on any particular date, you can expect us to announce both types of releases over the next 18 months.

Is it possible to order a machine based on the Unix operating system, read a short introductory manual, then turn it on and begin using it?

Our strategy thus far has been to look to our value-added reseller (VAR) customers to adopt the software to the specific needs of their customer base. To the extent their customers desire simplified administration and operating procedures, then we would expect VARs to provide them. As time goes on, we will directly respond to this desire if the marketplace wants us to.

Portability is an important attribute of Unix in theory. Is that portability but in reality where there are so many different versions of the operating system?

We agree that there is a need for a Unix system standard to assure users their investment in applications software is protected. That is why we, in response to user demands, have established System V as the standard.

Unix needs up to much memory. It's too powerful and simply inappropriate for the single-user micro environment. For optimum operation, the multitasking capability requires a 32-bit microprocessor and 384K RAM — horsepower far beyond the typical desktop.

It is true that most instances of the Unix system deployed today require more memory and horsepower than available in the majority of desktop computers. However, as silicon technology advances, the power of the desktop computer will increase, allowing more and more of the strengths of the Unix system to be capitalized on.

Coming as it from the other direction, AT&T is committed to unbundling the Unix system so as to provide our customers greater flexibility in packaging the system to meet their needs best. I think you will see these two trends coming together very nicely as workstations based on the next generation of 32-bit chips reach the marketplace in substantial quantities beginning in 1986.

System V was supposedly frozen, yet it was supplanted by Release 2 just one year later to fix bugs and upgrade. Do Unix's sheer size and complexity hinder widespread acceptance?

Unix System V Release 2.0, providing new functionality and performance improvements over Release 1.0, was issued as a fully upward-compatible release to Release 1.0. Our Unix system commitment is to maintain functionality and code compatibility from release to release while continuing to add new features and capabilities. Hence, our commitment to a standard is not intended to imply stagnation. With the technology evolving as rapidly as it is, a truly "frozen" operating system would fail to bring the users the potential afforded by new technology.

Even with the upgrades incorporated into Release 2, System V does not include features such as record

and file locking, which are considered necessary for a commercial environment, particularly in remote or distributed computing systems. Does AT&T plan to address these?

Our original user base was program development and engineering people supported by minicomputers executing the Unix system. In the mid- to late 1970s, we began to extend that user base by developing within AT&T a number of turnkey systems on top of the Unix operating system to support business applications in the former Bell operating companies.

Shortly thereafter, Unix system VARs began to do the same and provide systems to meet the needs of their commercial customers. Many of those system providers developed extensions such as record locking to the

Unix system to allow their offerings to meet the needs of their customer base. Over time, many of these features have been incorporated into our standard implementation.

You can expect this trend to continue — that is, we will continue to incorporate into the Unix system those features needed by our customers. For example, we expect to be offering generic record locking and demand paging features later this year. The power of the Unix system and our commitment to an open architecture is that it allows this to happen — that is, new technology can be developed by many different groups and the most successful and important elements of this new technology can be incorporated into our evolving standard implementation. There will always exist unsatisfied needs and new capabilities in extensions devel-

oped by others; we are committed to respond to these in a way that serves our customer base with quality and consistency.

How does the Unix system fit into AT&T's view of networking?

AT&T's networking approach for its computer, communications and Unix system products is very simple to state: We are committed to our open network architecture and endorse the international and de facto communications protocols.

A strategic thrust of our Unix system plan for the next few years will be to provide fundamental networking capabilities in a way that facilitates communications at all protocol levels between all vendor machines executing Unix System V. We believe this capability is essential to meet

"Intelligence...is the artificial objects, especia

This quote appeared in a 1978 issue of *The Bell System Technical Journal* that was devoted to a series of papers constituting the first complete description of the UNIX[®] operating system.

At that time, UNIX was used primarily by sophisticated programmers.

No longer. INTERACTIVE now offers UNIX software tools for every computer user: executives, engineers, office workers, and our oldest customers—those sophisticated programmers who have built UNIX into a major new force in the computer industry.

Here's how we built our enhanced version of UNIX.

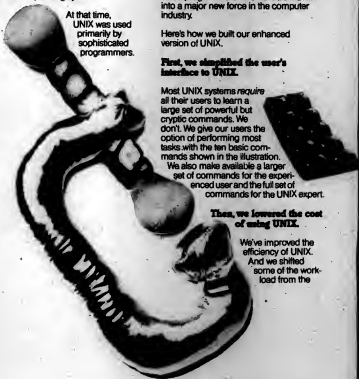
First, we simplified the user's interface to UNIX.

Most UNIX systems require all their users to learn a large set of powerful but cryptic commands. We don't. We give our users the option of performing most tasks with the ten basic commands shown in the illustration.

We also make available a larger set of commands for the experienced user and the full set of commands for the UNIX expert.

Then, we lowered the cost of using UNIX.

We've improved the efficiency of UNIX. And we shifted some of the workload from the



the needs of the office environment, which is becoming more and more heterogeneous in the way of computing devices.

The inherent strength of the Unix system architecture coupled with AT&T's overall communications expertise will, in my opinion, allow us to make very strong contributions in the area. This market need will mandate open communications architecture, and we are committed to deliver them.

Much of the discussion about Unix centers on its merits as an operating system and its advantages to programmers. What specific benefits do you see in a typical corporate environment?

Almost all applications today have an element of multiuser access. While

Once the user investment in applications is insulated from hardware, the customer will be king, able to select the best hardware at the lowest price to meet his need.

we do not expect these applications to be replaced overnight, we will see a trend toward using the Unix operating system for new applications.

In fact, there is one area that is ideally suited for both the multiuser and text handling aspects of the Unix operating system, and that is office automation.

Are you planning to offer a product in office automation?

Office automation products based on the Unix operating system are already in wide use inside AT&T. As a statement of direction, we have indicated that our strategic software and system products will be based on

Unix System V.

Stuart Muench, director of data systems marketing for AT&T Information Systems, has said about the Unix operating system and AT&T, "... as the inventor of the product, we have to be the best." Considering Microsoft Corp.'s *Windows*, however, you may say that System V is the best in the marketplace now or that an AT&T version ever will be?

Depending upon the particular needs of a customer, it is possible at any given time that versions of the Unix system other than System V might better meet a specific need. In general, in those cases where other versions meet an important customer need, you can expect us to see to it that our standard Unix system will be enhanced and will meet that need.

At the National Computer Conference in July, you said, "Our plan with computers is to follow the Unix system. We plan to move Unix down to micros and up to mainframes." Does that imply that AT&T will be coming out with a mainframe in the foreseeable future?

AT&T is always investigating and assessing various business opportunities. However, you should not construe my statement as an indication that AT&T will or will not be in the mainframe business in the foreseeable future.

If your plan is to take Unix down to micros, why did AT&T announce a personal computer based on MS-DOS?

As a first step, AT&T announced its MS-DOS-based personal computer, recognizing the widely available and popular application software written for this environment. In the interest of protecting customers' investments, our AT&T PC interface allows Unix System V communications with systems utilizing MS-DOS version 2.0 without users' having to learn any new interfaces. This will bring the power of Unix systems to the existing MS-DOS base of users. In the future, AT&T will be offering additional enhancements that will allow customers to make a smooth transition from their current system to systems based on Unix software.

How necessary is it to the success of Unix for IBM to give it more of an endorsement than just running it on its Personal Computer?

The Unix system has become popular over the past 10 years because of the many key features (portability, multiuser operations, background processing, file system, the shell, pipes, utilities and so on) that customers find attractive.

Because of the demands of the marketplace, most of the world's major computer companies are now licensed from us. Any computer vendor that makes a commitment to the Unix system is making a business decision to further its own interest — and, in our judgment, a pretty good one.

When you say that Unix can free users from "hardware tyranny" because it is portable, aren't you directly challenging IBM?

Unix will challenge the capability

faculty of making lly tools to make tools."

—Henri Bergson (1859-1941)

central processor to intelligent terminals. You can use our intelligent terminal or the IBM® Personal Computer to perform tasks normally assigned to a UNIX central processor.

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We started with our IS/3 system running on DEC™ PDP™ and VAX™ computers. And we refined our major tools so that they run as an extension to DEC's VMS™ operating system.

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of all hardware manufacturers, including AT&T. Once the user investment in applications is insulated from hardware (any make or generation of hardware), the customer will be king, then being able to select the best hardware at the lowest price to meet his need. All hardware vendors will have to deal with the new levels of customer freedom.

AT&T is coming late to computer marketing, but year late start allows you to design a product line that is compatible from top to bottom, based on Unix. With so many products released over so many years to fit so many purposes, IBM is not in such a position. Is this AT&T's competitive edge?

There are more negatives than positives coming to the commercial computer marketplace "late," as you put it. But we were operating under a consent decree that precluded us from being in this business commercially. However, we have been designing and building computers for the world's largest telecommunications networks for more than 30 years.

Specifically, however, we have introduced a new product line of AT&T 3B computers with an open architecture that facilitates interfacing with the large existing installed base of computers. Also, this product line has the advantage of a common operating system — Unix System V — and advanced communications capabilities (that is, PC Interface, AT&T 3BNet, AT&T Information System Network [ISN]) and AT&T strength and heritage.

Also, we are a resourceful company with a lot of talented people. AT&T inventions and advances, like the transistor and coding theory, set the technical foundations of the computer industry. It is great to be able now to complete products rather than just our technology.

AT&T's hands-off attitude toward Unix in the early years actually encouraged university students to experiment with the operating system and take their experience with them into business. But now AT&T has its hands on the marketing. What is the overall strategy to convince systems managers to turn to Unix — for instance, as an operating system that can solve the micro-mainframe link problem?

All of my comments to your last networking question apply here as well. In addition, the Unix system today executes on all size computers from small to very large.

This flexibility is conducive to native or "transparent" communications and sharing of resources, a cru-

cial reason for wanting to link workstations to mainframes. By providing application programs a standard environment for a wide variety of machine types and powerful networking capabilities, the next step in office automation can be taken.

And by providing the architecture and tools to allow interconnection with computers that are not running the Unix system, a fully integrated environment can be achieved.

Isn't it ironic that the operating system that AT&T ignored for so long is now the centerpiece of its computer strategy?

AT&T never ignored the Unix system. In fact, it has been used widely within the company including many of our switching and operations support system products.

For a long time, the consent decree prevented us from doing more with the Unix system.

In July, AT&T and Olivetti announced Unix Europe, described as a joint venture company to promote System V. What will Unix Europe do for customers?

Unix Europe is a London-based, joint AT&T-Olivetti venture created to service and expand the market for Unix System V in Western Europe.

Its activities will include:

1. Licensing the use of source code of Unix System V operating system and related software.

2. High-level technical support.

3. Specialized training.

4. Running the European operations of the Unix System V Library of Applications Software. (This library has been active in the U.S. since February of this year.)

It will provide AT&T European customers with faster service and shorter turnaround time.



In addition, on July 15, 1984, we also announced our Unix Systems Far East office, which will be resident in Tokyo and perform many of the same functions for the Far East as Unix Europe.

Is Unix spreading as fast outside the U.S. as inside?

The Unix system movement outside the U.S. is just taking hold, and thus we are seeing stronger growth rates from our international licen-

ing activity.

If we look at the AT&T licensed installed base of Unix systems, we see the following breakdown: 73% North America, 17% Europe, 9% Far East and 1% "other." However, the growth rates since early 1983 invert this order: 66% Far East, 53% Europe and 30% North America.

Hence, while the Unix systems growth rate in North America is certainly a healthy one, Europe and the

Far East are growing at about twice the North American rate. The formation of Unix Europe and Unix Far East offices will better service our international customers and amplify the further commercialization of the Unix system.

Here are a few dimensions of the present scope of this commercialization:

About 90,000 computers of approximately 125 different models from 80 different computer companies now run

Unix operating systems. The total number of installations is expected to increase by a factor of anywhere from two to six during 1984.

About 300 application packages are now available from more than 60 software companies, up by a factor of six over what was available in 1982. These include 50 accounting packages, 25 word processing packages, 16 graphics packages and 13 spreadsheets.

Vertical packages, such as

medical/dental, legal, manufacturing and real estate, also are starting to emerge.

It is estimated that about 100,000 programmers are now writing Unix operating systems software. Independent market analysts predict total Unix operating system business (software, hardware and support) to increase by about a factor of four by 1986—from a dollar value of about \$1.9 billion in 1983 to an estimate of more than \$8 billion in 1986. And this is only the beginning.

We've discussed many of Unix's problems and challenges in the future. Tell me what is so good right now about the operating system, particularly in comparison with others available?

The strengths are many, varied and deep and getting known to more and more people. Its portability across a wide variety of machine architectures and vendor products has been proven time and time again and continues to demonstrate the feasibility of achieving a standard having little dependency on the underlying hardware.

This leads to its second, and in my opinion most important, strength: application software portability. That is, software written to a Unix system can be moved from vendor A's computer model M to vendor B's computer model N with relatively little effort—something virtually unheard of in the industry up to now. This gives users the opportunity to protect their ever-growing investment in application software while continuing to take advantage of the best hardware price/performance the technology will support.

The ramifications to the industry should be dramatic, making the Unix operating system, from the standpoint of its impact on the industry, much more than just another operating system.

The third strength of the Unix system's open architecture relative to the networking needs of the industry has been discussed.

Finally, the classical strengths, such as the inherent multitasker and multitasking capabilities, pipes (which allow you to construct and link together the inputs and outputs of individual programs), file system, text processing and powerful productivity tools, to name but a few, continue to make it well suited to the needs of people accomplishing their day-to-day tasks.

Although many other operating systems have some features the Unix system does not have today, in my opinion none has the overall scope, flexibility and depth of Unix System V. I believe it is the leader today in terms of overall capability, and we are committed to keeping it there in the future.



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UNIX's INFANCY

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EVOLUTION OF UNIX SYSTEMS

Year	Internal release	External release
1972	Version 2	
1973	Version 3	
1974	Version 4	Unix V4
1975	Version 5	
1976	Version 6	Unix V6
1977	Programmer's Workbench (PWB)	PWB/Unix
1978	Version 7	Unix V7
1979	32V	Unix 32V
1980	PWB 2.0	
1981	Release 3.0	Unix System III
1982	Release 4.0	
1982	Release 5.0	
1983 (Int.)		Unix System V*
1984 (Int.)	Unix System V (Release 2.0)	Unix System V (Release 2.0)
1984 (Int.)	Unix System V/MSBCOO	Unix System V/MSBCOO**

* The first commercial version to be submitted by AT&T

** A part of Unix System V is the Motorola 68000 implementation — developed by Motorola, Inc. for AT&T.

never stopped. As Ritchie has stated, "What we wanted to preserve was not just a good environment in which to do programming, but a system around which a fellowship could form."

Thompson and Ritchie's initial attempt to develop an operating system began with a rewrite on the Digital Equipment Corp. PDP-7 of a game called Space Travel, first written on Multics. During this rewrite, the ground was laid for developing a common interpreter (shell).

In 1970, Unix was named — a takeoff on Multics. By whom? Brian Kernighan.

The next development was the writing of process control routines or system calls. DEC had just introduced the PDP-11, and Thompson and Ritchie decided that it was a better machine for their development

work. The orders not to develop an operating system still stood. To get around this problem, they proposed to build a system for editing and processing text for the patent department. And the "roof" text formatter was born, along with the first application to be offered on Unix.

Work continued in the early 1970s. All processes were initially written in assembly language. The first language to be developed for Unix was Thompson's language, intended to be a Fortran compiler. This language was the forerunner for C, which Ritchie developed in 1971.

In 1972, pipes and filters were introduced. In 1973, the Unix operating system kernel was rewritten in C.

One of the advantages of using a language that did not depend on specific machine language or assembly language was the ability to port the operating system to other hardware. This feature was understood early in the development of Unix. The goal was to make the kernel as machine-independent as possible and to isolate the machine-dependent portions to make them easy to change.

Asked about the evolution of Unix into a product, Ritchie said, "Our efforts involved a lot of teamwork. Unix attracted many users within the Labs whose work developing applications contributed ideas to improve and expand the capabilities."

Bud Wonesiewicz, an initial user of Unix at Bell Labs, said, "The experience was frustrating, but not in an unpleasant way. There were people around to help. It involved a lot of learning by trying things. An experimentalist likes to learn this way."

Ritchie and Thompson never intended to build a product to sell. When asked what had surprised him most about the success of Unix, Ritchie said, "The acceptance and usage of Unix is a lot larger than I expected. We expected the technical ideas to have an influence in the development of operating systems. What happened was not only an acceptance of the technical idea, but Unix itself was accepted."

Ritchie and Thompson received the 1983 Electronics Achievement Award — the first time in its nine-year history the award was given for software. And they received the 1983 Association for Computing Machinery Turing Award and the new Software System Award for their development of generic operating systems theory and the Unix operating system specifically.

Becoming a product

By the Justice Department's 1966 Consent Decree, AT&T was forbidden to engage in certain nonregulated activities. The company took a conservative position. To avoid being in the software business, it licensed the Unix software but did not support it. Thus, in the early 1970s, when universities began seeking for the Unix operating system, version 5 was made available. It was offered as a — no trial period, no warranties, no patent indemnification, no support or service, no maintenance and payment in advance.

The product was first licensed in 1973. Seventeen licenses were issued to universities, the first to the California Institute of Technology.

In 1974, the first commercial license (and first installation) was granted to the Rand Corp. The system's portability sparked commercial interest and, in 1975, the first com-

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Sample cENGLISH Program

IDENTIFICATIONS

MODULE: Minname

AUTHOR: bcs

DATE: 8/29/84

REMARKS: Sample cENGLISH program that adds first names to a file

END IDENTIFICATIONS

GLOBALS

FIXED LENGTH 1 ans

FIXED LENGTH 15 Fname

END GLOBALS

MAIN PROGRAM

BEGIN

CLEAR SCREEN

SET ECHO OFF

USE "NAMES"

VIEW BY "ID_NAME" ASCENDING

AT 23,1 SAY "Add a record? Y or N"

AT 23,25 ENTER ans USING "I"

WHILE ans EQ "Y"

CLEAR GETS

AT 6,1 SAY "Enter first name"

AT 6,20 GET Fname

USING "....."

READ SCREEN

INSERT

Fname = Fname

END INSERT

AT 12,10 SAY "Welcome to cENGLISH. " & Fname

WAIT

STORE " " TO Fname

STORE " " TO ans

AT 23,1 SAY "Add another record? Y or N"

AT 23,30 ENTER ans USING "I"

CLEAR ROW 1 THRU 23

END WHILE

AT 12,10 SAY "That's all for now"

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END PROGRAM

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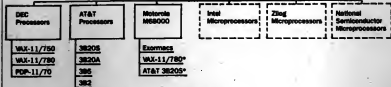
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- * Each package includes the right to utilize that source on one designated CPU.
- * Additional designated CPUs for licensed packages may be obtained for \$16,000 each.
- * Licensees having a source license for one additional package and sublicensing rights may designate additional source CPUs on the following schedule:

1-32 user system	\$1,000
1-64 user system	\$3,500
>64 user system	\$7,000

Current	Future
---------	--------

*Development systems

mercial vendor was issued a license, along with royalty schedules and distributor provisions for sublicensing. That vendor was Yourdon, Inc.

Other milestones were the introduction in 1980 of Unix on 16-bit microcomputers by Onyx Systems, Inc.; the porting of Unix to Amдах Corp.'s 470 series in 1981; and, in the same year, Microsoft Corp.'s Xenix port to the Tandem Corp. Model 16. Now Unix ran on hardware from micro through mainframes.

While the antitrust suit was in progress, AT&T was allowed to assume a larger role in marketing computers and related products. In November 1981, the Justice Department and AT&T announced a settlement that removed many of the 1966 Consent Decree restrictions. Licensing was moved from Western Electric to AT&T. In 1980, AT&T announced Unix System III, the first step in recognizing Unix as a product.

At the January 1983 Unix, System V and support were announced. Four months later at the National Computer Conference, AT&T announced that licenses were available for Unix on three microprocessors — the Motorola, Inc. 68000, Intel Corp. iAPX286 and National Semiconductor Corp. 16032. At the July 1983 Usenix conference, AT&T announced supported software packages: Instructional Workbench, Unix Tutorial and Writers Workbench, an aid for

technical writers.

Then on Jan. 13 of this year, IBM confirmed rumors by announcing the availability of Unix on its Personal Computer. When asked whether he felt that Unix needed IBM's stamp of approval to be legitimate, Dennis Ritchie said, "As a technical accomplishment, Unix has always been legitimate. Maybe from a marketing viewpoint, IBM has to approve something for it to be legitimate in the computer business. But I think that is a short-sighted viewpoint."

There are many other companies that believe in the legitimacy of Unix. Currently, 130 have licenses for and provisions to sublicense System V.

The growth in licenses and installations indicates that many believe the product is around to stay.

First followers

Clandestine development, lack of organized support and the seal of the original users all set the stage for a religious movement around this operating system.

Who were the first followers? Back in 1974, when the first few copies of Unix found their way into universities, a small group of programmers quickly became addicted. Some started to meet twice a year to exchange information about the operating system and the C language. Meetings at universities included Bell

Labs people and served as a forum for discussing changes and improvements.

Attendance grew from 20 to 200, and in 1980, the Usenix organization was born. Members exchange technical ideas. The group publishes newsletters six times a year and holds conferences twice a year. Headquartered

in El Cerrito, Calif., Usenix now claims more than 1,200 members.

While the technical people organized to exchange information, marketing people met to offer each other support in getting Unix off the ground as a product. About a dozen people, including Mike Florio, current president of /usr/group, began meeting in 1980 to fill the marketing void. They wanted a forum for discussing ways to increase the system's use, to create a source for positive publicity and to provide a stable base from which a Unix market could grow.

Incorporated in July 1981, /usr/group publishes a bimonthly newsletter and a catalog of Unix applications and related products. It holds yearly conferences, and membership has grown to about 2,000.

Unix has surpassed its developers' original goals — to provide a good development environment and to be as independent from hardware as possible.

Lee Sigler is a consultant in computer industries marketing with Technology Decisions, Inc. in Los Altos, Calif.

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IN THE BEGINNING...

(This article is adapted from "The Evolution of the Unix Time-Sharing System," by Dennis M. Ritchie, published in Lecture Notes in Computer Science, Vol. 70, Language Design and Programming Methodology, edited by Jeffrey M. Tobies, pages 25-35. Copyright © 1980 Springer-Verlag, Berlin-Heidelberg-New York.)

The Unix operating system has come into wide use, so wide that its very name has become a trademark of Bell Laboratories. Its important characteristics have become known to many people. It has suffered much rewriting and tinkering since the first publication describing it in 1974, but few fundamental changes. However, Unix was born in 1969, not 1974, and the account of its development makes a little-known and perhaps instructive story.

For computer science at Bell Laboratories, the period 1968-1969 was somewhat unsettled. The main reason was the slow, though clearly inevitable, withdrawal of the Labs from the Multics project. To the Labs computing community as a whole, the problem was the increasing obviousness of the failure of Multics to deliver promptly any sort of usable system, let alone the paces envisioned earlier.

For much of this time, the Murray Hill Computer Center was also running a costly General Electric Co. 646 machine that inadequately simulated the GE 635. Another shake-up that occurred during this period was the organizational separation of computing services and computing research.

From the point of view of the group that was to be most involved in the beginnings of Unix (K. Thompson, Ritchie, M.D. McIlroy, J.F. Osesana), the decline and fall of Multics had a directly felt effect. We were among the last Bell Laboratories holdouts actually working on Multics, so we still felt some sort of stake in its success. More important, the convenient interactive computing service that Multics had promised to the entire community was in fact available to our limited group, at first under the CTSS system used to develop Multics and later under Multics itself.

Even though Multics could not then support many users, it could support us, albeit at exorbitant cost. We didn't want to lose the pleasant niche we occupied, because no similar ones were available; even the time-sharing service that would later be offered under GE's operating system did not exist.

What we wanted to preserve was not just a good environment in which to do programming, but a system around which a fellowship could form. We knew from experience that the essence of communal computing, as supplied by remote-access, time-shared machines, is not just to type programs into a terminal instead of a keypunch, but to encourage close communication.

Thus, during 1969, we began trying to find an alternative to Multics. The search took several forms. We (mainly Osesana, Thompson and Ritchie) lobbied intensively for the purchase of a medium-scale machine for which we promised to write an operating system; the machines we suggested were the Digital Equipment Corp. PDP-10 and the Sigma Data

Systems (later Xerox Corp.) Sigma 7. The effort was frustrating, because our proposals were never clearly and finally turned down but yet were certainly never accepted.

Several times it seemed we were very near success. The final blow to this effort came when we presented an exquisitely complicated proposal, designed to minimize financial outlay, that involved some outright purchase, some third-party lease and a plan to turn in a DEC KA-10 processor on the soon-to-be-announced and more capable KI-10. The proposal was rejected, and rumor soon had it that W.O. Baker (then vice-president of research) had reacted to it with the comment, "Bell Laboratories just

doesn't do business this way!"

Actually, it is perfectly obvious in retrospect (and should have been at the time) that we were asking the Labs to spend too much money on too few people with too vague a plan. Moreover, I am quite sure that at that time, operating systems were not, for our management, an attractive area in which to support work. They were in the process of extricating themselves not only from an operating system development effort that had failed, but from running the local Computation Center. Thus, it may have seemed that buying a machine such as we suggested might lead on the one hand to yet another Multics or, on the other, if we produced



Dennis Ritchie



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something useful, to yet another Computation Center for them to be responsible for.

Besides the financial agitations that took place in 1969, there was technical work also. Thompson, R.H. Canaday and Ritchie developed, on blackboards and scribbled notes, the basic design of a file system that was later to become the heart of Unix. Most of the design was Thompson's, as was the impulse to think about file systems at all, but I believe I contributed the idea of device files.

Thompson's itch for creation of an operating system took several forms during this period; he also wrote (on Multics) a fairly detailed simulation of the performance of the proposed file system design and of paging behavior of programs. In addition, he started work on a new operating system for the GE-645, going as far as

writing an assembler for the machine and a rudimentary operating system kernel whose greatest achievement, so far as I remember, was to type a greeting message. The complexity of the machine was such that a mere message was a fairly notable accomplishment. But when it became clear that the lifetime of the 645 at the Labs was measured in months, the work was dropped.

Also during 1969, Thompson developed the game "Space Travel." Though it made a very attractive game, Space Travel served mainly as an introduction to the clumsy technology of preparing programs for the PDP-7. Soon Thompson began implementing the paper file system (perhaps "chalk file system" would be more accurate) that had been designed earlier. A file system without a way to exercise it is a sterile propo-

sition, so he proceeded to flesh it out with the other requirements for a working operating system, in particular, the notion of processes. Then came a small set of user-level utilities: the means to copy, print, delete and edit files and, of course, a simple command interpreter (shell).

Up to this time, all the programs were written using Gecon, and files were transferred to the PDP-7 on paper tape; but once an assembler was completed, the system was able to support itself. Although it was not until well into 1970 that Brian Kernighan suggested the name "Unix," in a somewhat treacherous pun on "Multics," the operating system we know today was born.

The PDP-7 Unix file system

Structurally, the file system of PDP-7 Unix was nearly identical to

today's. It had an i-list, directories and special files describing devices.

The important file system calls were also present from the start: read, write, open, creat (sic), close. With a few very important exceptions, discussed below, they were similar to what one finds now. A minor difference was that the unit of I/O was the word, not the byte, because the PDP-7 was a word-addressed machine. In practice, this meant merely that all programs dealing with character streams ignored null characters; because null was used to pad a file to an even number of characters. Another minor, occasionally annoying difference was the lack of erase and kill processing for terminals. Terminals, in effect, were always in raw mode. Only a few programs (notably the shell and the editor) bothered to implement erase-kill processing.

In spite of its considerable similarity to the current file system, the PDP-7 file system was in one way remarkably different: There were no path names, and each filename argument to the system was a simple name (without "/") taken relative to the current directory. Links, in the usual Unix sense, did exist. Together with an elaborate set of conventions, they were the principal means by which the lack of path names became acceptable.

The most serious inconvenience of the implementation of the file system, aside from the lack of path names, was the difficulty of changing its configuration. As mentioned, directories and special files were both made only when the disk was re-created. Installation of a new device was very painful, because the code for devices was spread widely throughout the system. For example, there were several keys that visited each device in turn. Not surprisingly, there was no notion of mounting a removable disk pack, because the machine had only a single fixed-head disk.

The operating system code that implemented this file system was a drastically simplified version of the present scheme. One important simplification followed from the fact that the system was not multiprogrammed. Only one program was in memory at a time, and control was passed between processes only when an explicit swap took place.

So, for example, there was an "iget" routine that made a named i-node available, but it left the i-node in a constant, static location rather than returning a pointer into a large table of active i-nodes. A precursor of the current buffering mechanism was present (with about four buffers), but there was essentially no overlap of disk I/O with computation. This was avoided not merely for simplicity. The disk attached to the PDP-7 was fast for its time — it transferred one 18-bit word every two microseconds. On the other hand, the PDP-7 itself had a memory cycle time of one microsecond, and most instructions took two cycles (one for the instruction itself, one for the operand).

However, indirectly addressed instructions required three cycles, and indirection was quite common, because the machine had no index registers. Finally, the direct memory access controller was unable to access memory during an instruction. The upshot was that the disk would incur overrun errors if any indirectly addressed instructions were executed

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while it was transferring. Thus, control could not be returned to the user nor, in fact, could general system code be executed with the disk running. The interrupt routines for the clock and terminals, which needed to be runnable at all times, had to be coded in very strange fashion to avoid indirection.

Process control

By "process control," I mean the mechanisms by which processes are created and used; today the system calls "fork," "exec," "wait" and "exit" implement these mechanisms. Unlike the file system, which existed in nearly its present form from the earliest days, the process control scheme underwent considerable mutation after PDP-7 Unix was already in use. (The introduction of path names in the PDP-11 system was certainly a considerable notational advance but not a change in fundamental structure.)

Today, the way in which commands are executed by the shell can be summarized as follows:

1. The shell reads a command line from the terminal.
 2. It creates a child process by "fork."
 3. The child process uses `exec` to call in the command from a file.
 4. Meanwhile, the parent shell uses "wait" to wait for the child (command) process to terminate by calling `exit`.
 5. The parent shell goes back to step 1.
- Processes (independently executing entities) existed very early in PDP-7 Unix. There were, in fact, precisely two of them, one for each of the two terminals attached to the machine. There was no fork, wait or `exec`. There was an `exit`, but its meaning was rather different, as will be seen. The main loop of the shell went as follows:

1. The shell closed all its open files, then opened the terminal special file for standard input and output (file descriptors 0 and 1).
 2. It read a command line from the terminal.
 3. It linked to the file specifying the command, opened the file and removed the link. Then it copied a small bootstrap program to the top of memory and jumped to it. This bootstrap program read in the file over the shell code, then jumped to the first location of the command (in effect an `exec`).
 4. The command did its work, then terminated by calling "exit." The `exit` call caused the system to read in a fresh copy of the shell over the terminated command, then to jump to its start (and thus in effect to go to step 1).
- The most interesting thing about this primitive implementation is the degree to which it anticipated themes developed more fully later. True, it could support nei-

ther background processes nor shell command files (let alone pipes and filters); but I/O redirection (via "<" and ">") was soon there; it is discussed below. The implementation of redirection was quite straightforward; in step 3 above, the shell just replaced its standard input or output with the appropriate file. Crucial to subsequent development was the implementation of the shell as a user-level program stored in a file, rather than a part of

the operating system.

The structure of this process control scheme, with one process per terminal, is similar to that of many interactive systems, for example CTSS, Multics, Honeywell TSS and IBM TSS and TSO. In general, such systems require special mechanisms to implement useful facilities such as detached computations and command files; Unix at that stage didn't bother to supply the special mechanisms.

It also exhibited some irritating, idiosyncratic problems. For example, a newly re-created shell had to close all its open files both to get rid of any open files left by the command just executed and to record previous I/O redirection. Then it had to reopen the special file corresponding to its terminal in order to read a new command line. There was no "/dev" directory (because no path names).

Moreover, the shell could

retain no memory across commands because it was reexecuted afresh after each command. Thus, a further file system convention was required: Each directory had to contain an entry "xy" for a special file that referred to the terminal of the process that opened it. If by accident one changed into some directory that lacked this entry, the shell would loop hopelessly, and just about the only remedy was to reboot. (Sometimes the missing link

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could be made from the other terminal.)

Process control in its modern form was designed and implemented within a couple of days. It is astonishing how easily it fit into the existing system. At the same time, it is easy to see how some of the slightly unusual features of the design are present precisely because they represented small, easily coded changes to what existed.

A good example is the separation of the fork and exec functions. The most common model for the creation of new processes involves specifying a program for the process to execute. In Unix, a forked process continues to run the same program as its parent until it performs an explicit exec. The separation of the functions is certainly not unique to Unix, and, in fact, it was present in the Berkeley time-sharing system, which was well-known to Thompson.

Still, it seems reasonable to suppose that it exists in Unix mainly because of the ease with which fork could be implemented without changing much else. The system already handled multiple (two) processes; there was a process table, and the processes were swapped between main memory and the disk. The initial implementation of fork required only:

1. Expansion of the process table.
2. Addition of a fork call that copied the current process to the disk swap area, using the already existing swap I/O primitives, and made some adjustments to the process table.

In fact, the PDP-7's fork call required precisely 27 lines of assembly code. Of course, other changes in the operating system and user programs were required, and some of them were rather interesting and unexpected. But a combined fork-exec would have been considerably more complicated, if only because exec, as such, did not exist; its function was already performed, using explicit I/O, by the shell.

The "exit" system call, which previously read in a new copy of the shell (actually a sort of automatic exec but without arguments), simplified considerably; in the new version, a process only had to clean out its process table entry and give up control.

Curiously, the primitives that became "wait" were considerably more

By the beginning of 1970, PDP-7 Unix was a going concern. Primitive by today's standards, it was still capable of providing a more congenial programming environment than its alternatives.

general than the present scheme. A pair of primitives sent one-word messages between named processes:

```
smes(pid, message)
(pid, message) ← rmes()
```

The target process of smes did not need to have any ancestral relationship with the receiver, although the system provided no explicit mechanism for communicating process IDs, except that fork returned to each of the parent and child the ID of its relative. Messages were not queued; a sender delayed until the receiver read the message.

The message facility was used as follows: The parent shell, after creating a process to execute a command, sent a message to the new process by smes. When the command terminated (assuming it did not try to read any messages), the shell's blocked rmes call returned an error indication that the target process did not exist. Thus, the shell's smes became, in effect, the equivalent of "wait."

A different protocol, which took advantage of more of the generality offered by messages, was used between the initialization program and the shells for each terminal. The initialization process, whose ID was understood to be 1, created a shell for each of the terminals and then issued "run"; each shell, when it read the end of its latest file, used smes to send a conventional "I am terminating" message to the initialization process, which re-created a new shell process for that terminal.

I can recall no other use of messages. This explains why the facility was replaced by the wait call of the present system, which is less general but more directly applicable to the desired purpose. Possibly relevant also is the evident bug in the mechanism: If a command process attempted to use messages to communicate

with other processes, it would disrupt the shell's synchronization. The shell depended on sending a message that was never received; if a command executed rmes, it would receive the shell's phony message and cause the shell to read another input line just as if the command had terminated. If a need for general messages had manifested itself, the bug would have been repaired.

At any rate, the new process control scheme instantly rendered some very valuable features trivial to implement: for example, detached processes ("&") and recursive use of the shell as a command. Most systems have to supply some sort of special "batch job submission" facility and a special command interpreter for files distinct from the one used interactively.

Although the multiple-process idea slipped in very easily indeed, there were some aftereffects that weren't intended. The most memorable of these became evident soon after the new system came up and apparently worked. In the midst of our

jubilation, it was discovered that the "chdir" (change current directory) command had stopped working. There was much reading of code and anxious introspection about how the addition of fork could have broken the chdir call.

Finally the truth dawned: In the old system, chdir was an ordinary command; it adjusted the current directory of the (unique) process attached to the terminal. Under the new system, the chdir command correctly changed the current directory of the process created to execute it, but this process promptly terminated and had no effect whatsoever on its parent shell. It was necessary to make chdir a special command, executed internally within the shell. It turns out that several command-like functions have the same property, for example, "login."

Advent of the PDP-11

By the beginning of 1970, PDP-7 Unix was a going concern. Primitive by today's standards, it was still capable of providing a more congenial programming environment than its alternatives. Nevertheless, it was clear that the PDP-7, a machine we didn't even own, was already obsolete, and its successors in the same line offered little of interest.

In early 1970, we proposed acquisition of a PDP-11, which had just been introduced by DEC. In some sense, this proposal was merely the latest in the series of attempts that had been made throughout the preceding year. It differed in two important ways. First, the amount of

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money (about \$66,000) was an order of magnitude less than what we had previously asked, second, the charter sought "was not merely to write some (unspecified) operating system, but instead to create a system specifically designed for editing and formatting text, what might today be called a word processing system."

The impetus for the proposal came mainly from J.P. Ossanna, who was then and until the end of his life interested in text processing. If our early proposals were too vague, this one was perhaps too specific; at first it, too, met with disfavor. Before long, however, funds were obtained through the efforts of L.E. McMahon, and an order for a PDP-11 was placed in May.

The processor arrived at the end of the summer, but the PDP-11 was so new a product that no disk was available until December. In the meantime, a rudimentary, core-only version of Unix was written using a cross-assembler on the PDP-7. Most of the time, the machine sat in a corner, emitting all the tired knight's tour on a 6-by-8 chess board — a three-month job.

Once the disk arrived, the system was quickly completed. In internal structure, the first version of Unix for the PDP-11 represented a relatively minor advance over the PDP-7 system; writing it was largely a matter of translation. For example, there was no multiprogramming; only one user program was present in core at any moment.

On the other hand, there were important changes in the interface to

Not only did the patent department adopt Unix, but we achieved enough credibility to convince management to acquire one of the first PDP-11/45s.

the user. The present directory structure, with full path names, was in place, along with the modern form of "exec" and "wait" and conveniences like character-erase and line-kill processing for terminals. Perhaps the most interesting thing about the enterprise was its small size: 34K bytes of core memory (16K for the system, 8K for user programs) and a disk with 1K blocks (512K bytes). Files were limited to 64K bytes.

At the time of the placement of the order for the PDP-11, it had seemed natural, or perhaps expedient, to promise a system dedicated to word processing. During the protracted arrival of the hardware, the increasing usefulness of PDP-7 Unix made it appropriate to justify creating PDP-11 Unix as a development tool, to be used in writing the more special-purpose system.

By the spring of 1971, it was generally agreed that no one had the slightest interest in scrapping Unix. Therefore, we translated the "root" text formatter into PDP-11 assembly language, starting from the PDP-7 version that had been translated from McIlroy's BCPL version

on Multics, which had in turn been inspired by J. Saltzer's "runoff" program on CTSS.

In early summer, editor and formatter in hand, we felt prepared to fulfill our charter by offering to supply a text processing service to the patent department for preparing patent applications. At the time, they were evaluating a commercial system for this purpose. The main advantages we offered (besides the dubious one of taking part in an in-house experiment) were two in number.

First, most Texttype Corp.'s Model 57 terminals, which, with an extended type-box, could print most of the math symbols they required; second, we quickly offered off with the ability to produce line-numbered pages, which the Patent Office required and which the other system could not handle.

During the last half of 1971, we supported three typists from the patent department — who spent the day busily typing, editing and formatting patent applications — and meanwhile tried to carry on our own work. Unix has a reputation for supplying interesting services on modest hard-

ware, and this period may mark a high point in the benefit/equipment ratio. On a machine with no memory protection and a single 5M-byte disk, every test of a new program required care and boldness, because it could easily crash the system, and every few hours' work by the typists meant pushing out more information onto DECTape because of the very small disk.

The experiment was trying but successful. The patent department adopted Unix, and thus became the first of many groups at the Laboratories to ratify our work, but we achieved sufficient credibility to convince our own management to acquire one of the first PDP-11/45 systems made. We have accumulated much hardware since then and labored continuously on the software.

Introducing pipes

One of the most widely admired contributions of Unix to the culture of operating systems and command languages is the "pipe," as used in a pipeline of commands. Of course, the fundamental idea was by no means new; the pipeline is merely a specific form of co-routine. Even the implementation was not unprecedented, although we didn't know it at the time. The "communication files" of the Dartmouth Time-Sharing System did very nearly what Unix pipes do, though they seem not to have been exploited so fully.

Pipes appeared in Unix in 1972, well after the PDP-11 version of the system was in operation, at the suggestion (or perhaps insistence) of

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McIlroy, a long-time advocate of the nonhierarchical control flow that characterizes co-routines. Some years before pipes were implemented, he suggested that commands should be thought of as binary operators whose left and right operand specified the input and output files. Thus, a "copy" utility would be commanded by:

inputfile copy outputfile

To make a pipeline, command operators could be stacked up. Thus, to sort "input," paginate it neatly and print the result off-line, one would write:

input sort paginate offprint

In today's system, this would correspond to:

sort input | pr | pr

The idea, explained one afternoon

on a blackboard, intrigued us but failed to ignite any immediate action. There were several objections to the idea as put: The infix notation seemed too radical (we were too accustomed to typing "cp x y" to copy x to y); and we were unable to see how to distinguish command parameters from the input or output files. Also, the one-input, one-output model of command execution seemed too confining. What a failure of imagination!

Some time later, thanks to McIlroy's persistence, pipes were finally installed in the operating system.

High-level languages

Every program for the original PDP-7 Unix system was written in assembly language, and bare assembly language it was — for example, there were no macros. Moreover, there was no loader or link editor, so

every program had to be complete in itself. The first interesting language to appear was a version of McClure's TMG that was implemented by McIlroy. Soon after TMG became available, Thompson decided that we could not pretend to offer a real computing service without Fortran, so he sat down to write a Fortran in TMG. As I recall, the intent to handle Fortran lasted about a week. What he produced instead was a definition of a compiler for the new language B. B was much influenced by the BCPL language. Other influences were Thompson's taste for spartan syntax and the very small space into which the compiler had to fit. The compiler produced simple interpretive code. Although it and the programs it produced were rather slow, it made life much more pleasant. Once interfaces to the regular system

calls were made available, we began once again to enjoy the benefits of using a reasonable language to write what are usually called "systems programs" — compilers, assemblers and the like. (Although some might consider the PL/I we used under Multics unreasonable, it was much better than assembly language.) Among other programs, the PDP-7 B cross-compiler for the PDP-11 was written in B, and in the course of time, the B compiler for the PDP-7 itself was transcompiled from TMG into B.

When the PDP-11 arrived, B was moved to it almost immediately. In fact, a version of the multiprecision "desk calculator" program "dc" was one of the earliest programs to run on the PDP-11, well before the disk arrived. However, B did not take over instantly. Only passing thought was given to rewriting the operating system in B rather than assembler, and the same was true of most utilities. Even the assembler was rewritten in assembler. This approach was taken mainly because of the slowness of the interpretive code. Of smaller but still real importance was the mismatch of the word-oriented B language with the byte-addressed PDP-11.

Thus, in 1971 work began on what was to become the C language. Perhaps the most important watershed occurred during 1973, when the operating system kernel was rewritten in C. It was at this point that the system assumed its modern form; the most far-reaching change was the introduction of multiprogramming. There were few externally visible changes, but the internal structure of the system became much more rational and general. The success of this effort convinced us that C was useful as a nearly universal tool for systems programming, instead of just a toy for simple applications.

Today, the only important Unix program still written in assembler is the assembler itself, virtually all the utility programs are in C and so are most of the application programs, although there are sites with many in Fortran, Pascal and Algol 68 as well. It seems certain that much of the success of Unix follows from the readability, modifiability and portability of its software that in turn follows from its expression in high-level languages.

One of the comforting things about old memories is their tendency to take on a rosy glow. The programming environment provided by the early versions of Unix seems, when described back, to be extremely harsh and primitive. I am sure that, if forced back to the PDP-7, I would find it intolerably limiting and lacking in conveniences. Nevertheless, it did not seem so at the time. The memory fixes on what was good and what lasted and on the joy of helping to create the improvements that made life better. In 10 years, I hope we can look back with the same mixed impression of progress combined with continuity.

I am grateful to S.P. Morgan, K. Thompson and M.D. McIlroy for providing early documents and digging up recollections.

Because I am most interested in describing the evolution of ideas, this article attributes ideas and work to individuals only where it seems most important. The reader will not, on the average, go far wrong if he reads each occurrence of "we" with unclear antecedent as "Thompson, with some assistance from me."

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AFTER SYSTEM V

C



The sheer size of Unix precludes its use as a truly universal operating system unless you remove personal computers from the universe.

In 1969. While Unix has undergone substantial revision and is an extremely stable and mature system, it is now 16 years old — almost ancient technology.

Unix was initially designed for one purpose: to be a hospitable environment for programmers who would know how to exploit its strengths and avoid its weaknesses. Now it is being touted as the perfect system for any and all business applications. But no one operating sys-

tem is perfect for everyone, just as no one programming language has ever proved ideal for all purposes. Many in the computer industry forget lessons of the past, notably the one that states, "People will not put up with unusable systems if something better is available."

Remember when everyone used punched cards for input and batch processing was the order of the day? Now we pay more attention to people's efficiency than the com-

puter's and use interactive, CRT-based systems whenever possible. The Unix system is based on this philosophy, making work easier (if you understand the principles).

But Unix is much more complex than other operating systems in wide use. While it is true that Microsoft Corp.'s MS-DOS and Digital Research, Inc.'s CP/M are far from the ideal user environment (and are limited in features, besides), they have the advantage of being simpler for a novice user to learn.

When comparing a full-blown system such as Unix to MS-DOS, it is important to remember that the latter is not a leading operating system because of its technically better features or even because it is easier to use. MS-DOS is an industry leader solely because of its association with the IBM Personal Computer (one might even consider that the Commodore 64 operating system is an industry leader for the same reason).

While several factors make the IBM Personal Computer a best-seller, remember that people tend to buy computers for solutions to their problems, not for the sheer joy of owning, programming and caring for their very own machine. People generally buy the IBM Personal Computer with MS-DOS because they can then easily run some of the thousands of good application programs that exist for it. To them, the only purpose of the operating system is to allow the use of the application program; the easier to use, the better.

Prediction: End users will not buy Unix-based systems in large quantities until they are convinced that such systems and their application programs offer significant advantages over other available machines. Furthermore, they will require a high level of compatibility with personal computers now marketed.

What's the real problem?

It's still not universally possible to order a Unix-based machine, read a short introductory manual, then turn it on and begin using it.

It's still not possible to go down to your local software store and buy an application program on a disk that can be dropped into your Unix system and poof! — it's installed.

It's still necessary to go through a long learning process to use Unix efficiently and an even longer one to manage the system adequately.

MS-DOS is not perfect in these three areas either, but facts and popular perception often differ.

The sheer size of Unix precludes its use as a truly universal operating system unless you remove personal computers from the universe. Unix has become such a large

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system (it includes not only the kernel, or executable program called Unix, but also about 7M bytes of utility programs) that the last successful "frozen" release from AT&T has already been supplanted by System V, Release 2, because of the numerous bug fixes and upgrades added.

System V does have many additions that make work easier for the system administrator and advanced user. Even so, current Unix System V does not include features such as record and file locking that are generally considered necessary for commercial operating systems. This lack has helped competing systems with these features, notably Microsoft's Xenix, capture a large share of the market. Other systems have begun to emerge as important market forces, most of them like Xenix, blatantly derived from Unix itself.

One, known as 4.2 BSD (written at the University of California at Berkeley), provides such superior performance over System V that it has become the de facto standard system on Digital Equipment Corp. VAX machines running Unix. Even DEC itself used 4.2 BSD as the basis for its implementation of Unix (called Ultrix). The 4.2 BSD system owes its speed to a technique known as "demand paging," which requires sophisticated hardware memory management. This hardware support, previously available only on machines such as the VAX, will become more common with the new generation of microprocessors.

More pressure is therefore on

UNIX SHOWS COMING UP

Here is a sample of major conferences scheduled for the next year that focus on Unix systems:

Oct. 16-18, 1984. Unix Expo at Marina Expo Complex and Sheraton Centre Hotel, New York, sponsored by Unigroup. Contact: National Expositions, 14 West 40th St., New York, N.Y. 10018. Will combine technical and marketing focus in 300 exhibits as well as three program tracks geared to the sophisticated end user.

Jan. 21-25, 1985. Uniform at Dallas Informatics, sponsored by /usr/group, Suite 200, 4655 Old Ironsides Drive, Santa Clara, Calif. 95054. Or contact conference manager: Professional Expositions Management Co., Suite 208, 2409 East Devon Ave., Des Plaines, Ill. 60018. Two hundred companies expected in 750 booths. Three program tracks will cover Unix and micros, office systems and market trends.

Jan. 22-25, 1985. Unixex conference, Fairmont Hotel, Dallas; shuttle buses will link this conference to Uniform exposition. Contact Judith Desharnais, Unixex Association Conference Office, P.O. Box 385, Sunset Beach, Calif. 90742.

June 11-14, 1985. Unixex Conference, Portland, Ore. Contact Judith Desharnais, Unixex Association Conference Office, P.O. Box 385, Sunset Beach, Calif. 90742.

The Berkeley version, known as 4.2 BSD, provides such superior performance over System V that it has become the de facto standard on VAX machines running Unix.

AT&T to include features like demand paging and record locking in new releases. It was previously speculated that System V would support these features; now AT&T watchers hope that System VI will. For the past few years, AT&T has announced new releases of Unix in January, so we might not have long to wait to

find out.

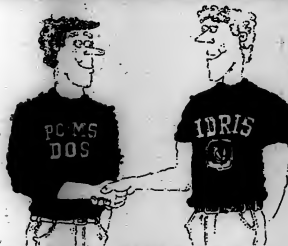
Technical considerations aside, the key to making Unix more palatable as a "universal operating system" comes back to the user interface. The software vendors in the Unix arena have mainly addressed other technologies like themselves; few companies have made an effort

to put ease of use and ease of installation high on their priority list.

AT&T has great technical strength and a large trained sales force, so it can be expected to influence the quality of offerings eventually. Still, IBM's growing support of the Unix system — versions are now available for the IBM Personal Computer, IBM 9002 and mainframe computers — may prove to be the most significant factor in the business world's acceptance of Unix.

David Fiedler edits the industry newsletter "Uniques," published by his firm, Infopro Systems, in Denver, N.J. He is also president of the Perichelli Corp., a market research and consulting firm that works with companies involved with Unix.

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